3. National Economic Development Analysis

3.1 Power System Impacts

3.1.1 Introduction

The section summarizes the findings in the Technical Report on Hydropower Costs and Benefits prepared by the Drawdown Regional Economic Workgroup Hydropower Impact Team (DREW Hydropower Impact Team, 1999). The purpose of this hydropower analysis was to identify the net economic costs associated with changes in hydropower production at the four lower Snake River facilities.

The scope of the hydropower impacts is large. Columbia River Basin hydropower projects serve as a major element in the Pacific Northwest electrical industry, and provide about 60 percent of the total regional energy needs and 70 percent of the total electrical generating capacity in the region on an average basis. The nature of hydropower is that it is available in different amounts from year to year depending on streamflow conditions. In wet years, the amount of hydropower generation can be significantly greater than the average conditions, and this energy (commonly referred to as secondary) can serve as a major part of the export market outside of the Pacific Northwest. In low water years, or high demand periods within a year, energy is often imported into the Pacific Northwest to meet the power demands. Consequently, any changes in the generation of Pacific Northwest hydropower could impact the amount of energy bought and sold, and the number of new generating facilities to be built, throughout the entire West Coast of the United States. For these reasons, the scope of this analysis is the entire western United States and parts of Canada as defined by the Western Systems Coordinating Council (WSCC). The WSCC is a one of nine regional energy reliability councils that were formed due to a national concern regarding the reliability of interconnected bulk power systems. The WSCC comprises all or part of the 14 Western States and British Columbia, Canada, over 1.8 million square miles.

The hydropower study was conducted jointly by staffs of the Corps and the regional power marketing agency, Bonneville Power Administration (BPA). As with other economic impact areas, an oversight group was formed to assist in the analysis and to provide a forum for interested parties to provide input. The Hydropower Impact Team (HIT) consisted of 10 to 20 members from numerous interested entities such as the Northwest Power Planning Council, the Bureau of Reclamation, National Marine Fisheries, regional tribes, river interest groups, and environmental groups. The HIT met regularly during the study to discuss appropriate approaches and assumptions to use in the analysis. The HIT also provided review and comments on drafts of the hydropower technical report.

The study process incorporated several elements to arrive at the estimate of economic effects associated with changes in hydropower with each of the alternatives. The process first considered how the impacted hydropower facilities currently function, and used system hydroregulation studies to estimate how much hydropower generation will occur with the different alternatives and different water conditions. This information was then incorporated into power system models to estimate how changes in hydropower generation will affect generation from other more costly power resources. Estimates of future market-clearing prices were also examined. The market price analysis examined economic effects by pricing the loss of hydropower generation based on the estimated future market prices for the base condition. A wide range of key study assumptions was investigated and the uncertainties associated with these assumptions were examined. Sensitivity tests were performed on some of the major study assumptions to assure that results were reasonable from a wide range of viewpoints. The financial impact on regional ratepayers and possible mitigation for these impacts were also investigated. The power system modeling tools were used to help identify the changes in air pollutant emissions with the different alternatives.

3.1.2 Hydropower Characteristics

The hydropower facilities of most interest to this study were the four lower Snake River facilities of Ice Harbor, Lower Monumental, Little Goose, and Lower Granite. However, almost all the hydropower projects in the Columbia-Snake system will be impacted under at least one of the alternatives being investigated. Table 3.1-1 describes some of the hydropower characteristics of each lower Snake River hydropower facility. Three of the lower Snake River facilities are essentially identical in terms of hydropower facilities. The Ice Harbor facility was constructed several years before the others and has less capacity. The overload capacity represents the maximum output that can be achieved. The average annual energy is presented in two different units: the average MW (aMW) which is the amount of generation averaged over all the hours of the year (8,760 hours), and the annual MWh which is the sum of all generation over the entire year. This energy data was taken from the average of 60 historic water years for the base condition.

Table 3.1-1. Hydropower Plant Characteristics

	Ice Harbor	Lower Monumental	Little Goose	Lower Granite	Lower Snake Totals
Number of Units	6.0	6.0	6.0	6.0	24.0
In-Service Date	1 (1961) 2 (1962) 3 (1975)	2 (1969) 1 (1970) 3 (1979)	3 (1970) 3 (1978)	3 (1975) 3 (1978)	
Energy:					
Average Annual Energy (aMW) for Base Condition	264	332	317	333	1,246
Average Annual Energy (1,000 MWh) for Base Condition	2,313	2,908	2,777	2,917	10,915
Plant Factor Base Condition (%)	38	36	34	36	36
System Energy Comparisons:					
Percent of Pacific Northwest Federal System Avg Energy (Fed System = 11,136 aMW) (%)	2	3	3	3	11
Percent of Total Pacific Northwest System Avg Energy (System = 24,479 aMW) (%)	1	1	1	1	5
Capacity:					
Nameplate Capacity Per Unit (MW)	3 (90) 3 (111)	135	135	135	
Total Nameplate Capacity (MW)	603	810	810	810	3,033
Overload Capacity (Total Maximum Output) (MW)	693	931	931	931	3,486
System Capacity Comparisons:					
Percent of Pacific Northwest Federal System Peaking Capacity (Fed System – 23,824 MW) (%)	3	4	4	4	15
Percent of Total Pacific Northwest System Peaking Capacity (System = 47,859 MW) (%)	1	2	2	2	7

Figure 3.1-1 shows an estimate of the average monthly generation of the four lower Snake River plants by month based on a system hydroregulation model for the base condition (Alternative 1, Existing Conditions). The amount of generation from these plants can change significantly in different water years (WY) and seasons. The figure compares the monthly generation for a 60-year average simulation (from year 1929 to 1988), a low water year (1930-31), and a high water year (1955-56).

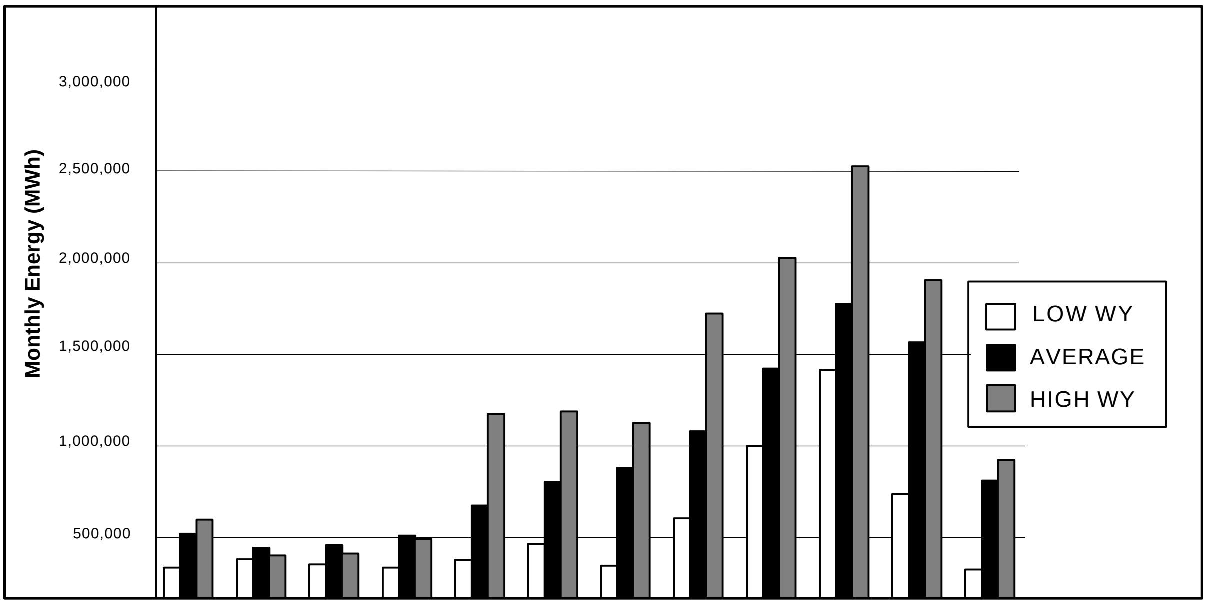

Figure 3.1-1. Alternative 1, Existing Conditions Results - Monthly Generation - 4 Snake River Dams Low WY (1930), High WY (1955-56) & 60 Year Average

Figure 3.1-2 presents the monthly generation-duration curve based on the 60 water year conditions from 1928 to 1988, for the base condition. The generation in this figure is the combined monthly generation of the four lower Snake River facilities. This figure shows the percent of time in which average monthly generation equals or exceeds the generation in MW. For example, the monthly generation equals or exceeds 1,000 MW about 50 percent of the months of the 60 water years, and equals or exceeds 2000 MW about 20 percent of the time.

The hourly operation of the lower Snake River plants is determined primarily by the amount of Snake River water arriving at Lower Granite because the four reservoirs have very limited storage capability and only minor tributary inflows into the other reservoirs. The ability to store water over the week, month, or season cannot occur at these facilities. The facilities can somewhat shape the amount of generation throughout the day with the limited storage within the top 3 to 5 feet of operating range over the juvenile fish non-migrating periods of November through March.

3.1.3 Power System Characteristics

Table 3.1-2 demonstrates to what extent each power-generating source is used in the Pacific Northwest. As can be seen in the table, hydropower makes up about 67 percent of the Pacific Northwest's total generating capacity, followed by coal. Next in terms of capacity available to meet demand is the import over the intertie system from regions outside of the Pacific Northwest. The firm energy amount shown in this table reflects that which can be generated in the low water year of 1936-37. The year 1937 has been defined as the critical year for defining firm energy in many regional power planning studies.

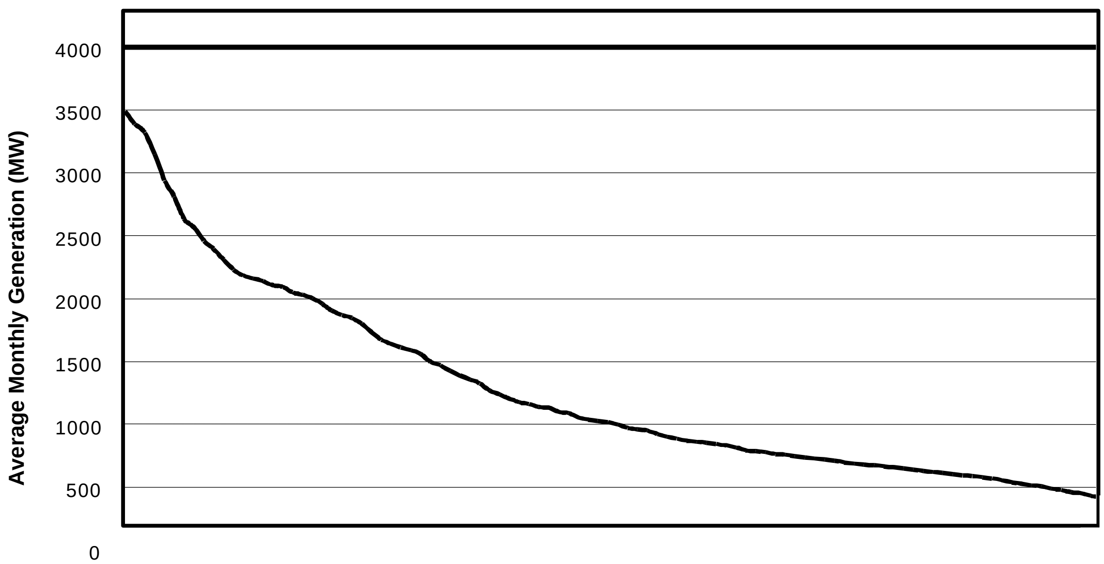

Figure 3.1-2. Lower Snake River Plants - Monthly Generation Duration

Table 3.1-2. The Pacific Northwest Electric Generating Resources 1997[1/]

Resource Type	Sustained Peak Capacity[2/] (MW)	% of Total Capacity	Firm Energy[2/] (aMW)	% of Firm Energy
Hydro	25,887	67	12,187	57
Coal	4,521	12	4.061	19
Nuclear	1,162	3	841	4
Imports	2,996	8	1,669	8
Combustion Turbines	1,665	4	753	4
Non-utility Generation	1,166	3	1,051	5
Cogeneration	775	2	675	3
Other	264	1	171	1
TOTAL	38,436	100	21,408	100

1/ Source: BPA's *1997 FAST FACTS*

2/ For more information see BPA's *Pacific Northwest Loads & Resources Study*

A distinction is often made between firm (also referred to as primary) energy and non-firm (referred to as secondary) energy in power markets because the firm energy can be counted on even in the most extreme historical low water years.

Table 3.1-3 provides generation and capacity information for the entire WSCC, based on actual generation in 1997, rather than the firm energy. The most prominent source of generating capacity and energy in the WSCC is hydropower, but to a significantly less extent than in the Pacific Northwest. Coal and natural gas driven thermal plants provide a much larger share of capacity and energy in the WSCC than in the Pacific Northwest. However, hydropower makes up the vast majority of system capacity and generation in the Pacific Northwest, and is the largest contributor for the entire WSCC.

Table 3.1-3. Western Systems Coordinating Council (WSCC) Electric Generating Resources, 1997

Resource Type	Capacity (MW)	% of Total Capacity	1997 Energy (aMW)	% of Total Energy
Hydro-Conventional	61,043	39	33,367	39
Hydro-Pump Storage	4,316	3	533	1
Steam – Coal	36,325	23	28,378	33
Steam – Oil	746	<1	239	<1
Steam – Gas	23,241	15	5,018	6
Nuclear	9,258	6	7,472	9
Combustion Turbine	5,846	4	206	<1
Combined Cycle	3,777	2	779	1
Geothermal	3,060	2	2,270	3
Internal Combustion	293	<1	-	<1
Cogeneration	8,119	5	5,954	7
Other	1,891	1	1,317	2
Pump-Storage Pumping			(445)	-1
Total	157,915	100	85,089	100

Source: 1998 WSCC Information Summary

3.1.4 Hydroregulation Models

The first step in defining the power impacts was to identify the amount of hydropower generation with each alternative. The second step was to identify the economic effects of changes in the hydropower.

The study utilized two system hydroregulation models to perform the first step. The system hydroregulation models simulate the operation of hydropower plants with each alternative with historical water conditions encountered over 50 or 60 water years, depending on which model is used. The models were used to define the power impacts at each hydropower plant in the Pacific Northwest with the alternative operations of the system. The model used by the Corps was the Hydro System Seasonal Regulation Program (HYSSR) and the BPA model was the Hydro Simulator Program (HYDROSIM). The major output of either model was a month-by-month hydropower generation amount from each hydropower plant in the Columbia Basin, for each of the years simulated by the models. See Appendix G, Hydroregulations, of the Feasibility Report for a detailed description of the hydroregulation models.

Table 3.1-4 summarizes the total monthly Pacific Northwest system generation amounts for each of the alternatives as compared to the base case condition, Alternative 1, Existing Conditions. This table provides the monthly averages over all the water year simulations done by the HYSSR (60 years) and HYDROSIM (50 years). The table shows the total hydropower production in the Pacific Northwest (System Generation). The HYSSR and HYDROSIM models have slightly different definitions of which hydropower facilities are included in the Pacific Northwest system generation, and hence the total system generation amounts are slightly different. These differences in system-wide hydropower generation estimates are used later in this analysis to define the economic effects of each alternative. Sections 1 and 3 of Table 3.1-4 show the average system generation for each alternative from the HYSSR and HYDROSIM models. However, the most important element of this study is the change in generation from the base condition. Sections 2 and 4 show the change in generation from the base condition (Alternative 1, Existing Conditions) with each alternative. The last section in the table presents the differences in net generation as defined by the two hydroregulation models. The differences in two models' estimation of change in generation with each alternative are relatively small, on average, but can be significant for specific months and alternatives.

Table 3.1-4. Hydropower Analysis: HYSSR and HYDROSIM Results by Alternative—System Generation (aMW)

HYSSR Results: Average Generation Over 60 Water-Year Simulations

Alternatives	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	ANN. AVG.
1	9,466	9,520	10,414	14,071	16,800	15,200	13,820	15,846	18,729	18,834	13,725	11,997	14,038
2 and 3	9,467	9,533	10,418	14,078	16,803	15,203	13,820	16,006	19,049	19,139	13,743	12,008	14,108
4	9,046	8,953	10,021	12,867	15,987	14,098	11,794	13,437	16,314	16,703	12,728	11,280	12,771

System Impacts HYSSR

(Generation Difference From A1; Negative Means Loss In Energy From Alternative 1)

Alternatives	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	ANN. AVG.	% OF ALT.1
2 and 3	1	13	4	7	3	3	0	160	320	305	18	11	70	0.5
4	(420)	(567)	(393)	(1,204)	(813)	(1,102)	(2,026)	(2,409)	(2,415)	(2,131)	(997)	(717)	(1,267)	(9.0)

HYDROSIM Results: Average Generation Over 50 Water-Year Simulations

Alternatives	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	ANN. AVG.
1	10,572	11,558	12,735	15,935	19,669	16,435	14,858	17,777	20,487	19,960	15,333	13,108	15,702
2 and 3	10,572	11,558	12,735	15,935	19,671	16,435	14,858	17,927	20,732	20,202	15,343	13,108	15,756
4	10,183	10,865	12,244	15,031	18,677	15,324	13,057	15,676	18,168	17,923	14,220	12,352	14,477

System Impacts HYDROSIM

(Generation Difference From A1; Negative Means Loss In Energy From Alternative 1)

Alternatives	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	ANN. AVG.	% OF ALT. 1
2 and 3	0	0	0	0	2	(1)	0	150	245	241	11	0	54	0.3
4	(389)	(693)	(491)	(904)	(992)	(1,111)	(1,801)	(2,101)	(2,319)	(2,037)	(1,112)	(755)	(1,225)	(7.8)

Differences in Impacts Between HYSSR and HYDROSIM (Negative Means HYSSR Difference is Larger)

Alternatives	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	ANN. AVG.	% OF A1
2 and 3	(1)	(13)	(4)	(7)	(1)	(4)	0	(10)	(75)	(64)	(7)	(11)	(16)	(0.1)
4	31	(126)	(98)	300	(179)	(9)	225	308	96	94	(115)	(38)	42	0.3

3.1.5 Power System Models

The study team used several models in the analysis. Figure 3.1-3 provides a schematic of how the several models were integrated to estimate the range of net economic effects. Specifics of each model are provided in the technical report (DREW Hydropower Impact Team, 1999). In general, the results from the

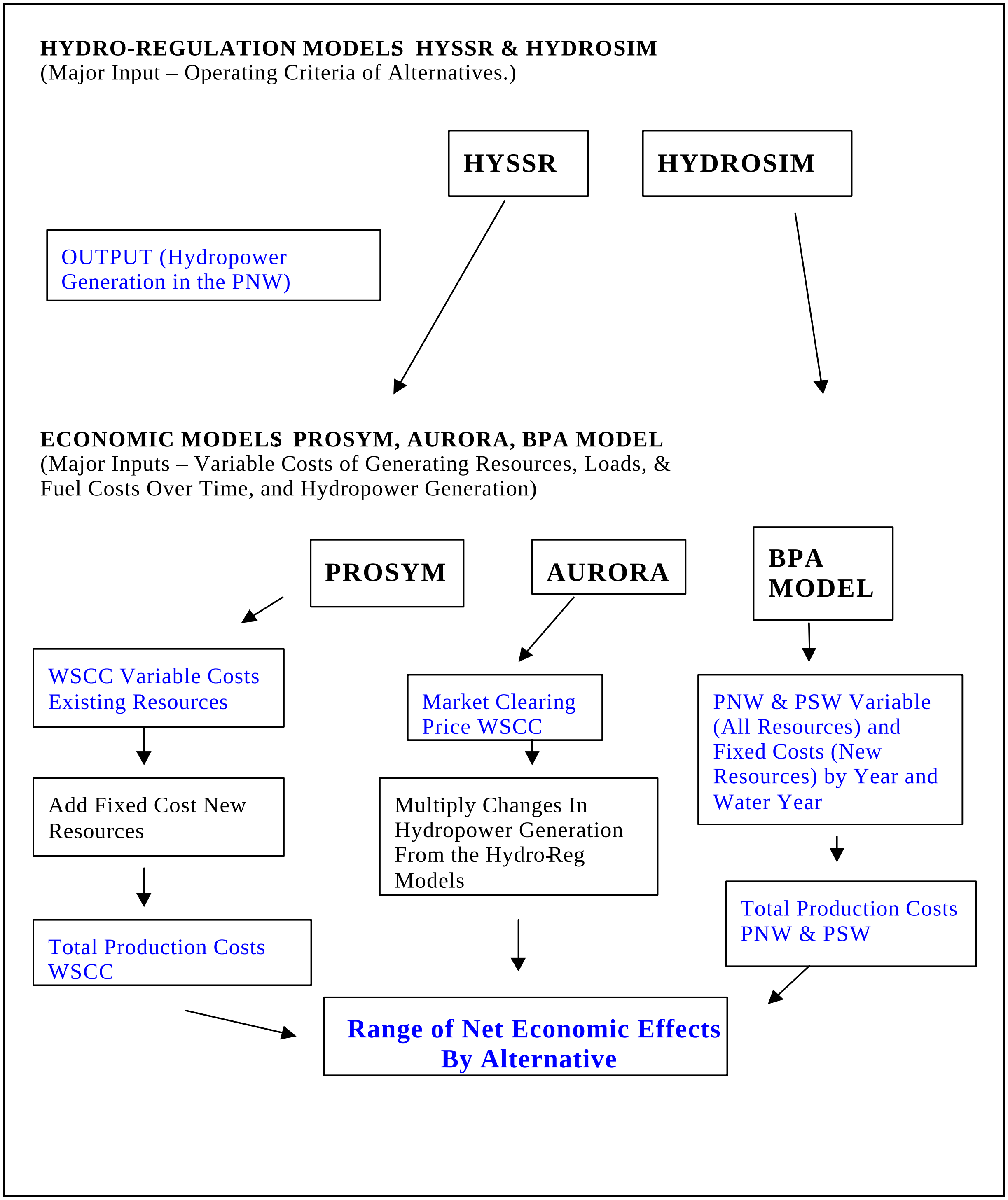

Figure 3.1-3. Schematic of Models Used in Hydropower Analysis

hydroregulation models were fed into the economic models. Each economic model was used to place a dollar value on the changes in hydropower production.

Because of the inter-related, market driven nature of the electric industry, it was decided that the evaluation of changes in hydropower production in the Pacific Northwest must be evaluated on a system-wide basis. This study uses two separate system production cost models, one by the Corps and one by BPA, to evaluate the net economic effects of changing power generation at the four lower Snake River facilities and John Day. A third approach developed by the Northwest Power Planning Council (NPPC) was also utilized in this study.

These multiple approaches were undertaken to look at the impacts from different analytical viewpoints to assure that the economic effects are adequately bracketed in the final estimates. The study progressed by examining model results for each alternative with the different system approaches. To the extent possible the basic input assumptions were standardized among the models, and these assumptions are discussed below. Upon comparing results, the study team built a consensus on the best analytical approach.

The evaluation of the net economic effects on hydropower was based on two basic approaches: a market price analysis and a system production cost analysis. The AURORA model served as the basic tool for the market price analysis, and the PROSYM and BPA models were used for the system production costs analysis. It is important to note that the market price and system production cost approaches are intended to measure the same net economic effects, and hence are directly comparable.

Many similarities do exist in the three power system models used in this analysis. They are all designed to identify how the different power generating resources will be operated to meet projected power loads (demand). They do vary in scope from hourly models (Aurora and PROSYM) to a monthly model that stratifies hours in the month into different blocks of peak and non-peak hours. The geographic regions covered by each model are different. The treatment of constructing new power resources and retiring power plants varies among the models. The primary outputs of each model are different. The Aurora model identifies the marginal cost in each period and this is assumed to be the market-clearing price. PROSYM provides the production costs (variable costs) to meet loads by all regions in the WSCC. The BPA model also identifies production costs but also provides the fixed costs of new resources to arrive at the total system production costs.

3.1.5.1 Market Price Model

The conceptual basis for evaluating the benefits from energy produced by hydropower plants is society’s willingness to pay for the outputs, which sometimes can be obtained through market prices. With the movement towards a more competitive market, the price of electricity in the California market and elsewhere is being priced at or near the marginal production cost of the last resource to provide the needed electricity. So, this part of the power analysis looked at valuing the incremental changes of hydropower generation at the market price, which was based on the marginal cost of the last resource used to meet load in the specific time frame.

As more competitive electricity markets develop, prices will not be set to average costs as they have been in the past. Rather, the various services provided, operating reserves, voltage stabilization, etc., will be available and priced separately. However, consumers will not have to purchase all of these services from separate suppliers. During most time periods in the power spot market, the generation price of electricity will be set by the operating costs of the most expensive generating unit needed to meet demand, or what is referred to in economics as the "marginal cost" of production. In general, a supplier will not be willing to sell power below the market price of the most expensive facility operating at a given time, because consumers will be willing to pay the higher price. Similarly, consumers will be unwilling to pay more than the cost of the most expensive operating available generator, since other suppliers will be offering lower prices. With prices set to marginal costs, the market will clear: all suppliers willing to provide power and all consumers willing to purchase power at the market price will be doing so.

Market prices were obtained from the NPPC study (NPPC, June, 1998) entitled "Analysis of the Bonneville Power Administration's Potential Future Costs and Revenues, 5 June, 1998." The market prices used in this study were developed with a model called Aurora, developed by a private firm, EPIS, Inc. The general elements of the Aurora model are provided here, and a more thorough description of Aurora is contained in the technical report (DREW Hydropower Impact Team, 1999). One of the principal functions of Aurora is to estimate the hourly market-clearing price at various locations within the WSCC.

Aurora estimates prices by using hourly demands and individual resource operating characteristics in a transmission-constrained chronological dispatch algorithm. The operation of resources within the WSCC is modeled to determine which resources are on the margin for each area in any given hour.

Aurora uses operating cost information for all the generating plants in the WSCC to build a least cost dispatch for the WSCC to meet energy demands. Units are dispatched according to variable cost, subject to non-cycling and minimum run constraints until hourly demand is met in each area. Transmission constraints, losses, wheeling costs and unit start-up costs are reflected in the dispatch. The market-clearing price is then determined by observing the cost of meeting an incremental increase in demand in each area. All operating units in an area receive the hourly market clearing price for the power they generate.

The hourly market clearing prices are developed on an area-specific basis. The analysis for this appendix uses the Oregon/Washington (OR/WA) area price to value Pacific Northwest generation. This price can be interpreted as the average busbar price as seen by generation in the OR/WA area. Charges for delivery within the OR/WA area are not included in the price.

3.1.5.2 System Production Cost Models

The other approach to define net economic effects was a system production cost analysis. The economic effects were identified by comparing system production costs with the level of hydropower production from the different alternatives being investigated. Changes in hydropower generation result in different levels of operation of more costly thermal generating power plants. Hence, the economic values of different increments of hydropower energy were defined by the displacement of thermal resource generation.

For this analysis the total system production costs are defined as the sum of the variable operating costs (production costs) and the fixed costs (annualized capital costs) of new resources added to meet loads. The total system is defined by different geographic regions in each model. However the basic definition is:

Total System Production Costs	**=**	**Variable Costs**	**+**	**Fixed Costs**
		(Production)		(New Capacity)

Both BPA and the Corps have models that estimate the costs of meeting energy demand (loads) with available hydropower energy and thermal resources. The models identify the most cost-effective way to meet loads given all system constraints. These models estimate which resources will be operated to meet loads and the variable costs of these resources are summed to define variable production costs. Loads may also be met through purchase of energy from the Pacific Northwest, Pacific Southwest, or other regions. The purchase price reflects the variable generation costs and the transmission costs of the resource used to provide the energy. Production costs in the Pacific Northwest and Pacific Southwest will vary depending on how much Columbia River hydropower is generated. The output of hydroregulation models (HYSSR and HYDROSIM) served as the major input to the system energy production cost models.

The BPA model categorizes West Coast thermal resources into several production cost blocks based on the average efficiencies of the plants. The more inefficient plants tend to be the older plants that are operated last in the dispatch order. The BPA model compares the Pacific Northwest and Pacific Southwest loads to the monthly hydropower and thermal generation for each simulation year. As hydropower generation varies, the thermal generation amounts and costs change. The model identifies the marginal costs of the resources which hydropower will displace. The load is broken into three distinct periods of each week or month. These periods are the super peak (hours 7:00 a.m. to 10:00 a.m. and 5:00 p.m. to 8:00 p.m. each weekday), peak (hours 6:00 a.m. to 10:00 p.m. Monday through Saturday, not including the super peak hours) and non-peak hours (the remainder of the week). This stratification accounts for the significant variations in prices and resources used to meet loads in these different periods of the week.

The Corps utilized an existing proprietary hourly system production model entitled PROSYM, which has been used extensively by the Corps throughout the United States. PROSYM was developed and is maintained by Henwood Energy Services of Sacramento, California. The Corps used the model under a contract with Henwood. The PROSYM model has an extensive database, which includes operating characteristics of all WSCC power plants, current fuel prices, plant efficiencies, and inter-regional marketing conditions. The model dispatches thermal and hydropower resources on an hourly basis to meet energy demand. Hydropower resources are based on weekly energy amounts generated by the hydropower regulator models from the facilities in the study region, or weekly energy amounts input to the model. The model also includes a pollution emissions subroutine.

3.1.5.3 Model Inputs

This section describes the major inputs utilized by the system production cost models and the market price analysis. Most of these key model assumptions were taken from the NPPC's report "*Analysis of the Bonneville Power Administration's Potential Future Costs and Revenues, 5 June 1998* range of projections (low, medium and high) was made for each key variable to account for the uncertainty associated with predicting future conditions.

Elasticity of Demand. One major simplifying assumption made in this analysis is that consumers of electricity have a zero price elasticity of electricity demand. This assumption does not account for the probable reduction in demand for electricity that will occur if electricity prices increase with the implementation of Alternative 4, Dam Breaching. There is significant evidence that there is price elasticity for electricity at both the wholesale and retail level. But, it was considered beyond the scope of this study to estimate elasticity for each consumer type.

System Loads

The system loads, or power demands, are shown in Table 3.1-5 for the starting year of 1997, by each of the 12 Aurora demand regions.

Table 3.1-5. Aurora Model - 1997 Electric Loads by Demand Region

Region	Load (aMW)
OR/WA	16779
North CA	10730
South CA	16783
Canada	11842
ID	2644
MT	1554
WY	1455
CO	4681
NM	2106
AZ	6474
UT	2481
NV	2817
TOTAL	80346

Source: NPPC's study, "Analysis of the Bonneville Power Administration's Potential Future Costs and Revenues,

Demand was assumed to grow at equal rates in all of the demand areas. Although this will certainly not be the case, the team did not research every state's demand forecasts because these were likely to include a wide range of basic demographic assumptions. It was also felt that historical relative growth rates for states might not be a good indicator of future demand growth.

For the medium case, demand was assumed to grow at 1.5 percent annually. In the low case, the assumption was 0.5 percent per year, and in the high case it was 2.5 percent. The load forecasts project the Pacific Northwest demand in terms of average megawatts by year up to year 2020.

Fuel Prices

The major component of production cost of any power system is the costs of fuels expended to generate the electricity. Hence, the fuel prices assumed to occur over time are a critical element of the system production cost modeling and the market price analysis. This section describes the assumptions made for the fuel prices in the different regions of the WSCC.

Natural Gas Prices

The NPPC Aurora model is currently structured to develop its natural gas price assumptions based on two pricing points, Henry Hub in Louisiana and Permian in Texas. Prices in the Aurora regions are then based on a series of differentials from these trading hubs. The results of making the differential adjustments are shown in Table 3.1-6. This table shows the assumed natural gas prices on a $/million BTU basis for 1997.

Table 3.1-6. Assumed 1997 Natural Gas Prices by Region

Regions	Estimated 1997 Price ($/mBTU)
Canada	1.45
BC Border at Sumas	1.70
Northwest from Alberta Eng Co. (AECO)	1.63
N. California from AECO	1.95
Utah	1.80
Colorado	1.95
Wyoming	1.80
Montana	2.00
Idaho	1.97
Southern California	2.15
Arizona	2.10
New Mexico	1.95
Nevada	2.00

The final assumption for natural gas prices was the real escalation rate applied to the gas prices. Three different future economic scenarios were projected. For the medium economic forecast case, it was assumed the medium gas price escalation included in the Council's power plan, 0.8 percent per year escalation above general inflation. The low forecast assumed a negative 1.0 percent real escalation rate, while the high projection assumed a positive 2.0 percent real escalation. These assumptions translate into similar growth rate in all regions with one exception. In 1999 and 2000 significant expansions to pipeline capacity to export from Alberta to the East are expected to come online. This expanded export capacity will have the effect of increasing prices in Alberta and British Columbia, perhaps significantly. To reflect this it was assumed that the basis differential from Canadian markets to Henry Hub decreases in the medium case. The Alberta Energy Company (AECO) Hub price in Alberta decreases from a negative $0.65 to a negative $0.45 by the year 2001. The Sumas differential decreases from a negative $0.55 to a negative $0.40 during the same period. These differential decreases result in significant increases to Northwest natural gas prices in the early years of the analysis. A range of natural gas assumptions is explored in the analysis as presented Table 3.1-7.

Oil Prices

For the base year of 1997 it was decided to use the starting crude oil prices at $3.50 per MMBtu with a low real escalation rate of 0.5 percent per year. This escalation rate was applied to all oil fuels. The 1997 starting values that were selected for other oil fuels are shown in Table 3.1-8.

Because oil prices do not appear to play an important role in determining the future market price of electricity, oil prices ranges were not used in the analysis.

Table 3.1-7. Summary of Natural Gas Price Assumptions

1997 Price	Low ($)	Medium ($)	High ($)
Henry Hub	1.80	2.00	2.25
Permian	1.60	1.80	2.15
Basis Differential			
AECO	-.65 constant	-.65 down to -.45	-.65 down to -.20
Sumas	-.55 constant	-.55 down to -.40	-.55 down to -.10
	(%)	**(%)**	**(%)**
Escalation Rates	-1.0	+0.8	+2.0

Table 3.1-8. Fuel Oil 1997 Prices Used in Analysis

Fuel Oil Type	1997 Price ($/MMBtu)
Crude Oil	3.00
#1 Fuel Oil	5.00
#2 Fuel Oil	4.50
#3 Fuel Oil	4.25
#4 Fuel Oil	3.85
#5 Fuel Oil	3.50
#6 Fuel Oil	2.70

Coal Prices

The other fuel, besides natural gas, that plays a significant role in the market price of electricity is coal. It was assumed that coal prices would decline in real terms in the base and low cases and to remain constant in the high case. In the low case coal prices were assumed to decline by 2 percent a year. In the base case, they decline at 1 percent a year. These growth rates were based on the Energy Information Administration's *Annual Energy Outlook*.

Resources; Existing and Future

To meet load growth over time it was necessary to project what kind of resources will be built in the future, and under what conditions these will be built. Each of the three models used in this analysis approached the addition of new thermal resources in different manners as discussed in the Fixed Production Cost section (Section 3.1.6.1). The type of resources to be added to the system was reviewed by the study team. It was found that the most predominate type of fuel plant that has been recently added to power systems on the West Coast have been natural gas-fired combined-cycle combustion turbine (CC) plants. It was found that CC natural gas plants represented the most cost-effective new additions over a wide range of potential plant factors. It was assumed in the Corps and BPA models that all new thermal resources to be built through year 2017 would be natural gas-fired combined cycle power plants.

The NPPC as part of its Power Plan responsibilities keeps abreast of the latest construction and operating costs for all potential resources. The construction costs identified for CC plants of 250 MW capacity in the West Coast region were estimated to be $601 per kW of installed capacity, at the 1998 price level. The average heat rate of the new CC plants in 1998 was assumed to be 7,045 Btu/kWh. This heat rate was assumed to go down over time at the rate of change described in the next section. The construction costs were based on the most recent financing experienced by the industry. To include these costs in the annual simulations, the construction costs were adjusted to an annual fixed cost amount. The fixed costs used in the BPA model were in the 11.4 to 11.9 mills/kWh range, depending on the year of simulation. For comparison purposes the annualized values of the construction and fixed O&M costs for gas powered combined-cycle powerplants, computed from a model developed by FERC, were used only in the PROSYM studies. The annualized value used in the PROSYM study was $86/kW-yr delivered to the distribution system.

Combustion Turbine Costs and Technology

Because new capacity additions are comprised of CC power plants, an effort was made to develop plausible and consistent assumptions regarding the evolution of the cost and performance of these plants over the study period.

Continuing advances in aerospace gas turbine applications are expected to lead to further reduction in the cost and increases in the efficiency of power generation equipment. For this study, cost reduction assumptions are based on projected improvement in gas turbine specific power[1/]. Increases in specific power produce greater output with no increase in physical size, thereby reducing cost. Historical rates of improvement and estimated ultimately achievable rates of specific power suggest that over the study period specific power will continue to improve, on average, at constant rates. The resulting projections of annual cost reduction averaged a negative 0.6 percent in the Medium forecast, a negative 1.2 percent in the Low and a negative 0.1 percent in the High forecast. These reductions were applied to both capital and operating costs of new CC plants.

State-of-the-art combined-cycle efficiency is forecasted to continue to improve, but at declining rates. Rates of efficiency improvement are based on alternative introduction dates of advanced turbine technologies, and decades by which ultimate turbine efficiency might be achieved. Using this approach, combined-cycle plant efficiencies would improve from 48 percent in 1997 to 54 percent by 2020 in the Medium forecast, to 57 percent in the Low and to 53 percent in the High forecast.

Unserved Load

In each of the three models, not all load was met in each time period. The amount of load to be met by the available resources is a fixed input to each of the models. The models then identify the most cost-effective way to meet that load given the resources available to the model. System simulations are run with the different water years, and the amount of available energy to serve load can vary substantially with the different water years. Since the models were trying to meet load in every hour, or block of hours, there were instances in which not enough energy or capacity was available to meet each hourly demand.

Different approaches were taken to account for the economic costs of the unserved load. In the real world, if shortages like this occur, the system will start shedding loads by not meeting certain loads,

[1/] Specific power is the power output per unit mass of working fluid.

and curtailing the amount of energy provided in a particular time frame to some or all electric customers. There will clearly be an economic cost associated with this curtailment. One approach considered for this study was to simply assign a relatively high cost for every shortfall in satisfying the load. This high value was assumed to represent a proxy for the economic cost of curtailment. Another approach used was to recognize that demand-side management measures could be instituted to reduce peak load during these critical hours.

Although it is likely that the market will come up with innovative approaches to reducing peak demands in response to time of use pricing, it was assumed that the market could achieve up to 26 percent as the maximum peak reduction through demand side voluntary actions.

The NPPC developed a supply curve for demand-side resources based on the best available information. This supply curve was used in the Aurora model and is presented in Table 3.1-9.

Table 3.1-9. Demand-side Supply Curve

Step	Share of Potential (%)	Mills/KWh
Step 1	First 20	50
Step 2	Second 20	100
Step 3	Third 20	150
Step 4	Fourth 20	250
Step 5	Last 20	500
Step 6	Unserved Peak	1000

3.1.6 Net Economic Effects by Alternative

As described above, two different approaches were undertaken to estimate the net economic effects associated with changes in hydropower production in the Pacific Northwest system: production costs and market pricing.

3.1.6.1 System Production Costs Analysis

The economic effects provided in this section are based on the system production costs as defined by the two production cost models. A range of results is presented based on three assumptions of the key variables of fuel costs and loads. The future condition hereafter referred to as Low, combines the lowest estimate of fuel prices, the most rapid advancement in generation technology, and the low estimate of future load growth for all regions in the WSCC. Likewise, the Medium conditions combined the medium projections of fuel price, technology advancement, and load. The High condition combined the high projections of these three parameters.

Many of the tables in this section provide the description of total system production costs for each alternative as estimated by the BPA model and the PROSYM model. As can be seen from these tables, the BPA model was run over a much broader range of assumed conditions. This is a spreadsheet model, which has considerable flexibility. The PROSYM model is a much more complex hourly model, and time constraints did not allow for running this model for the full range of potential future conditions. Another major difference in the two models is that the BPA model was run for each of the 50 historic water years, while the PROSYM model was only run for an average water year based on the average of all 60 water years simulated by the HYSSR model. The scope of the BPA model is the Pacific Northwest and California, while the PROSYM model includes all of the WSCC region.

The terminology used here refers to variable and fixed costs, and this is similar to the energy and capacity costs used in other studies. Energy is defined as that which is capable of doing work, and is measured over a time period. Electrical energy is usually measure in kilowatt-hours (kWh), megawatt-hours (MWh) or average MW (aMW - the average of MW produced over the entire year of 8,760 hours). Capacity is the maximum amount of power that a generating plant can deliver, usually expressed in kilowatts or megawatts. In the system production costs the variable costs are the costs associated with meeting energy requirements and they go up and down, as energy is needed to meet demand. The fixed costs are the costs needed to provide new capacity and this does not vary with hourly production. The fixed costs represent the annualized value of constructing the new capacity.

Variable Production Costs

The variable costs include the fuel costs and the variable operating costs of the many different thermal plants. If energy is transmitted between market regions, the cost associated with this transmission is also included in the variable production costs. Table 3.1-10 provides a summary of the variable production costs by generating resources as estimated by the BPA model for one specific year (2010), the medium forecast condition, the average of 50 water years, and two alternatives: Alternative 1, Existing Conditions, and Alternative 4, Dam Breaching. Table 3.1-11 provides the same type of information from the PROSYM model. These are provided as samples to demonstrate the nature of the estimated production costs for the Pacific Northwest and California in the BPA model and the entire WSCC in the PROSYM model. Similar results were computed for all the future years of 2002 to 2017, for the low, medium, and high conditions, and for each of the 50 water years with the BPA model. Comparing the total variable production costs for year 2010 for Alternative 1, Existing Conditions, and Alternative 4, Dam Breaching, shows that variable costs with Alternative 4, Dam Breaching, increase by $160 million and $202.6 million for the BPA and PROSYM models, respectively.

The results of the BPA model as shown in Table 3.1-10 are provided by resource type in the Pacific Northwest. Some thermal plants in the Pacific Northwest are classified as must run thermal which must be run due to the nature of the plant (i.e., nuclear) or long term contracts which require a constant level of production except during routine re-fueling and scheduled maintenance periods. The generation from these plants will not vary with the different alternatives, so the variable costs are not included in the table. The generation and variable costs from Pacific Southwest resources are presented in total in this table. The amount of generation from new CC plants is shown for Alternative 1, Existing Conditions, and Alternative 4, Dam Breaching. However, more new CC plants were assumed to be constructed with Alternative 4, Dam Breaching, to replace some of the lost hydropower generation and capacity. The costs associated with transmitting energy between regions are also reported in this table.

Table 3.1-10. BPA Model System Production Costs

Year 2010, With HYDROSIM & BPA Model, Medium Forecast			
Variable Production Cost Summary With Alternative 1			
		Variable Costs	**Average Var. Costs**
Pacific Northwest PLANTS:			
High Cost Coal	647	98.7	17.40
Low Cost Coal	2,414	207.0	9.79
Existing CT	55	11.2	23.26
Existing CC	1,594	214.7	15.37
New Region CC	5,135	609.4	13.55
Regional Firm Imports	1,477	120.0	9.27
Regional Hydropower	15,701	-	-
Curtailment/Demand-Side	89	48.7	62.72
TOTAL Pacific Northwest:	**27,113**	**1,309.7**	
Pacific Southwest PLANTS:			
Existing Resources	8,066	1,654.4	23.41
New Region CC	3,075	388.3	14.42
Curtailment/Demand-Side	103	50.9	56.21
TOTAL Pacific Southwest:	**11,244**	**2,093.7**	
TRANSMISSION COSTS		31.5	
TOTAL VARIABLE COSTS		**3,434.9**	
Variable Production Cost Summary With Alternative 4			
		Variable Costs	**Average Var. Costs**
Pacific Northwest PLANTS:			
High Cost Coal	659	100.4	17.40
Low Cost Coal	2,436	208.8	9.79
Existing CT	53	10.8	23.26
Existing CC	1,658	223.4	15.37
New Region CC	6,063	722.9	13.61
Regional Firm Imports	1,480	120.3	9.27
Regional Hydropower	14,477	-	-
Curtailment/Demand-Side	78	42.9	63.10
TOTAL Pacific Northwest:	**26,904**	**1,429.5**	
Pacific Southwest PLANTS:			
Existing Resources	8,249	1,692.6	23.42
New Region CC	3,094	390.7	14.42
Curtailment/Demand-Side	111	54.9	56.52
TOTAL Pacific Southwest:	**11,454**	**2,138.2**	
TRANSMISSION COSTS		27.5	
TOTAL VARIABLE COSTS		**3,595.3**	
Differences from Alternative 1 (Alternative 4 - Alternative 1)			
		Variable Costs	**Average Var. Costs**
Pacific Northwest PLANTS:			
Must Run	-	-	N/A
High Cost Coal	12	2	N/A
Low Cost Coal	21	2	N/A
Existing CT	(2)	(0)	N/A
Existing CC	64	9	N/A
New Region CC	928	114	N/A
Regional Import	3	0	N/A
Regional Hydropower	(1,225)	-	N/A
Curtailment/Demand-Side	(11)	(6)	N/A
TOTAL Pacific Northwest:	**(209)**	**120**	N/A
Pacific Southwest PLANTS:			
Must Run	-	-	N/A
Existing Resources	183	38	N/A
New Region CC	19	2	N/A
Curtailment/Demand-Side	7	4	N/A
TOTAL Pacific Southwest:	**209**	**45**	N/A
TRANSMISSION COSTS		(4)	N/A
TOTAL VARIABLE COSTS		**160.4**	N/A

Table 3.1-11. PROSYM Production Cost Summary by Area, Year 2010 Conditions—Average of Water Years, Medium Forecast Conditions, 1998 $ Million

Transmission Area	Alternative 1 Total Area Production Costs ($)	Alternative 3 Total Area Production Costs ($)	Alternative 3 minus 1 Area Production Costs ($)
Alberta	693.8	698.7	4.9
Arizona	1,977.0	1,977.1	0.1
BC Hydro	270.8	269.4	(1.4)
Comision Federal de Electricidad	681.0	674.8	(6.2)
Colorado/Wyoming	1,053.8	1,054.1	0.3
El Paso	97.2	97.1	(0.1)
Imperial Irrigation	51.3	51.3	(0.0)
Inland Northwest	543.7	553.3	9.6
Los Angeles Dept. of Water & Power	526.2	523.8	(2.4)
Montana	337.0	342.3	5.3
Northern California	3,266.9	3,272.3	5.4
Pacific Northwest	1,175.1	1,348.9	173.8
Palo Verde	978.3	978.2	(0.1)
Public Service of New Mexico	825.7	826.1	0.4
Southern California Edison	2,825.6	2,825.6	0.0
San Diego Gas & Electric	750.2	750.0	(0.2)
Southern Nevada	897.6	897.3	(0.3)
Utah	731.5	734.2	2.7
Wyoming	262.0	262.4	0.4
Total	17,944.7	18,136.9	192.2

One point of importance is how the loss in hydropower with Alternative 4, Dam Breaching (and other alternatives) is accounted for in these models. From Table 3.1-10 it can be seen that the HYDROSIM model estimated that with Alternative 4, Dam Breaching, that the amount of hydropower production was less than with Alternative 1, Existing Conditions, by 1,225 average MW. This difference in hydropower generation was made up by a combination of thermal alternatives (primarily natural gas-fired combined-cycle combustion turbines) at a higher cost. It is these higher variable costs that made up the increased production costs, and a large component of the net economic effects.

Table 3.1-10 demonstrates that with the breaching of the four lower Snake River dams and the building of additional CC plants in the Pacific Northwest, the total generation in the Pacific Northwest in year 2010 will be 209 aMW less than in the base condition. At the same time, the generation in the Pacific Southwest will increase by 209 aMW to meet the 2010 loads in the Pacific Northwest and Pacific Southwest regions. So, on an annual basis, the Pacific Northwest will import an additional 209 aMW from the Pacific Southwest in 2010 with Alternative 4, Dam Breaching.

The system variable production costs shown in Table 3.1-11 from the PROSYM model is the combination from each of the 14 transmission areas within the WSCC.

The variable costs for hydropower generation in both power production cost models are shown as zero for all alternatives. This is because there is no cost of fuel for hydropower. It is recognized that there will be some differences in fixed O&M and capital costs for hydropower between the different alternatives, but these are not included in this hydropower analysis. The implementation costs analysis does include the differences in hydropower O&M and capital costs with all alternatives and including them in this hydropower analysis would have resulted in double-counting this impact. The interested reader is referred to the Implementation Cost section of this Appendix.

Fixed Production Costs

This section discusses the capacity costs, or the fixed costs. For either of the production cost models to meet the loads projected over time, new generating facilities will need to be constructed. With each alternative, a different mix of new generating facilities will be needed to account for the varying amounts of hydropower production. The decision of when and how much new capacity is to be built is an important element of the analysis.

On a simplified basis the market driven capacity addition decisions will probably be based on the following considerations. The market-clearing price for any selected time period will generally be based on the marginal costs of the last resource. Only during periods of extremely high demand (peak demand), typically on very hot summer (or cold winter) days, when the demand for electricity approaches the available generating capacity, would prices rise above the marginal costs of the most expensive generator operating. Because the amount of capacity available at any point in time is fixed, and new generating capacity cannot be built quickly, the only way in which demand and supply could be kept in balance during extremely high demand periods would be through an increase in the price, to a level that would encourage some consumers to reduce their usage. The frequency of these periods of high prices will help determine whether new generating resources will be built. The price adjustment during periods of peak demand can be thought of as representing the value consumers place on reliability.

This price signaling concept and the frequency of occurrence formed the decision criteria for construction of new resources in the BPA and Aurora models used in this power analysis. With these models new resources are assumed to be built when the marginal costs are sufficiently high and frequent to cover the cost of constructing the resource (in terms of the annualized fixed costs) and the variable operating costs. The BPA model, for example, first simulates each year without any new resources being added in that year. The model then tests to see if it is economically justified to add new resources. To be justified a new power unit must produce enough energy in that year at the marginal costs to equal or exceed the fixed and variable costs of the new resource. If the resource is economically justified it is added to resource mix and the model continues this process until an optimized amount of new resources is identified. The interest rates used in the BPA model for new capacity additions were based on the same financial assumptions used by the Pacific Northwest Power Planning Council in the last draft of the regional power plan. The interest rates were based the most recent interest rates experience by merchant plant operators.

This economic justification approach was used in this study to estimate how many new resources would be built with each of the study alternatives, on a year-by-year basis from the present to year 2017. The additional fixed costs are included as a component of the total system production cost for identifying the net economic effects of each alternative. These costs are similar to the traditional capacity costs identified in past studies. Table 3.1-12 presents the resource additions projected to occur based on the BPA model results, which were also used in the PROSYM analysis.

Table 3.1-12. Power Resource Additions by Alternative BPA Model Results for Specific Years

	2010			**2018**		
Alternative	**Pacific Northwest (aMW)**	**Pacific Southwest (aMW)**	**TOTAL (aMW)**	**Pacific Northwest (aMW)**	**Pacific Southwest (aMW)**	**TOTAL (aMW)**
1	5,390	3,260	8,650	8,720	8,770	17,490
2 and 3	5,380	3,190	8,570	8,710	8,760	17,470
4	6,210	3,260	9,470	9,700	8,750	18,450
			DIFFERENCE FROM BASE CONDITION (aMW)			
2 and 3	(10)	(70)	(80)	(10)	(10)	(20)
4	820	-	820	980	(20)	960
			DIFFERENCE FROM BASE CONDITION (MW)			
2 and 3	(10)	(80)	(90)	(10)	(10)	(20)
4	890	-	890	1,070	(20)	1,040

Note: Includes all capacity additions up to and including this year.

It should be noted that this analysis identified only one power replacement scenario in which energy and capacity losses were replaced with natural gas fired CC plants. This was done because these were determined to have the lowest costs without considering any costs for the resulting increase in air pollution. Clearly, other options for replacement power could be considered and these could have lower air quality impacts, but they would likely have higher costs. Such options could include conservation. The Hydropower Impact Team is investigating the possibility of a conservation option, but this analysis was not completed in time for this appendix.

Total System Production Costs

Table 3.1-13 summarizes the total system production costs compared to Alternative 1, Existing Conditions, from the two models for year 2010, the medium projection condition, and the average over all water years. The total system production costs includes the variable costs of operating all the resources in year 2010 (column 2) and the fixed costs (column 4) associated with the additions of new resources that are needed to meet the projected load in that year. The variable costs in any given year include the operating costs for the resources added that year, and all resources in place in that year including new resources built prior to that date. The fixed costs are the annualized capital costs of new capacity. For example, with the BPA model the 820 aMW of new capacity under Alternative 4, Dam Breaching, was added up to year 2010 over the base condition. The annual fixed costs of this additional capacity was $88 million. The total system production costs in 2010 for Alternative 4, Dam Breaching, were the combination of the variable costs of $160 million and the fixed costs of $88 million.

Table 3.1-13. Hydropower Analysis: Total System Production Cost Summary

HYDROSIM & BPA Models				
Alternative	**Variable Production Costs (1998 $ Million)**	**Additional CC Capacity[1/] (aMW)**	**Additional Annual Fixed Costs (1998 $ Million)**	**Total System Production Costs (1998 $ Million)**
2 and 3	(0)	(80)	(8)	(8)
4	160	820	88	248
HYSSR & PROSYM Models				
Alternative	**Variable Production Costs (1998 $ Million)**	**Additional CC Capacity[1/] (aMW)**	**Additional Annual Fixed Costs (1998 $ Million)**	**Total System Production Costs (1998 $ Million)**
2 and 3				
4	203	820	77	280

1/ Includes all capacity additions up to and including this year. This is average MW. To determine total new capacity, divide by the availability factor of 92 percent. For example, for A3 the new capacity up to and including 2010 is 890 MW (820/.92)

Note: Year 2010 simulation, medium forecast conditions. Costs compared to Alternative 1, Existing Conditions.

Table 3.1-14 presents the system production costs on a year-by-year basis for the medium projection condition. This table also provides the total present worth values for each alternative and the average annual costs based on the three different discount rates.

Table 3.1-15 provides the average annual production cost for each alternative and the low, medium, and high projection conditions.

The comparison of the BPA and PROSYM production cost models can be made with results shown in Tables 3.1-13 and 3.1-14. Because PROSYM is much more complicated model to operate, and the results were similar to the BPA model, it was not run for all study alternatives. PROSYM modeling was limited to the medium forecast conditions and average water year. Consequently, many of the tables in this section do not include PROSYM results for all scenarios. However, the study team considered the PROSYM results to be a valuable crosscheck of the other modeling results and it was a useful tool to test many elements of this study.

Table 3.1-14. Hydropower Analysis: Total System Production Costs Over Time

Year	A2 ($ million)	A3 ($ million)
	HYDROSIM & BPA Model	
2005	0	0
2006	0	0
2007	0	242
2008	(8)	244
2009	(8)	246
2010	(8)	248
2011	(8)	249
2012	(9)	251
2013	(9)	253
2014	(9)	254
2015	(9)	257
2016	(9)	259
2017	(9)	261
2018	(9)	261
2019 - 2104	(9)	261
Results:		
NPV at 0%	(936)	25,963
NPV at 4.75%	(191)	5,347
NPV at 6.875%	(132)	3,705
Avg Annual at 0%	(9)	260
Avg Annual at 4.75%	(9)	256
Avg Annual at 6.875%	(9)	255
	HYSSR & PROSYM	
2005	N/A	0
2006	N/A	0
2007	N/A	239
2008	N/A	253
2009	N/A	266
2010	N/A	280
2011	N/A	283
2012	N/A	286
2013	N/A	289
2014	N/A	291
2015	N/A	294
2016	N/A	297
2017	N/A	300
2018	N/A	300
2019 - 2104	N/A	300
Results:	N/A	
NPV at 0%	N/A	29,779
NPV at 4.75%	N/A	5,526
NPV at 6.875%	N/A	3,658
Avg Annual at 0%	N/A	298
Avg Annual at 4.75%	N/A	265
Avg Annual at 6.875%	N/A	252

Note: Differences from Alternative 1. 1998 real million dollars, starting at in-service date, medium production cost assumptions.

Table 3.1-15. Hydropower Analysis: Average Annual Total System Production Costs

Alternative	Low	Med	High	Alternative	Med
Average Annual Costs at Discount Rate 6.875%					
	Production Costs HYDROSIM & BPA Model ($)			**Production Costs HYSSR & PROSYM ($)**	
Alternative	**Low**	**Med**	**High**	**Alternative**	**Med**
2 and 3	(6)	(9)	(12)	A2	
4	187	255	329	A3	252
Average Annual Costs at Discount Rate 4.75 %					
	Production Costs HYDROSIM & BPA Model ($)			**Production Costs HYSSR & PROSYM ($)**	
Alternative	**Low**	**Med**	**High**	**Alternative**	**Med**
2 and 3	(6)	(9)	(12)	2 and 3	
4	187	256	332	4	265
Average Annual Costs at Discount Rate 0 %					
	Production Costs HYDROSIM & BPA Model ($)			**Production Costs HYSSR & PROSYM ($)**	
Alternative	**Low**	**Med**	**High**	**Alternative**	**Med**
2 and 3	(6)	(9)	(13)	2 and 3	
4	186	260	339	4	298

Note: Results from two different models. 1998 real million dollars, various in service dates, 100-year analysis. All amounts are cost differences from Alternative 1, Existing Conditions..

3.1.6.2 Market Price Analysis

The electric industry is moving towards a more competitive market, but is currently in a transition period which mixes wholesale pricing at marginal costs with most retail pricing based on average costs, and established contracts that may or not reflect either of these approaches. For these reasons, this appendix provides results from the two approaches of system production costs in the previous section and the market prices in this section.

To evaluate each of the alternatives, the market prices from Aurora, as defined by the marginal costs, are applied to the difference in Pacific Northwest hydropower generation from the base condition (Alternative 1, Existing Conditions). Since the marginal cost varies by transmission area and by time periods, the study team had to select which market prices would be most appropriate to evaluate impacts. The study team chose to multiply changes in Pacific Northwest hydropower generation by the Aurora market price developed for the states of Oregon and Washington. This price most accurately reflects the value of Pacific Northwest energy.

The marginal costs vary by hour, by day, and by month. To simplify the analysis hourly prices were allocated to peak and non-peak periods and averaged for each month to obtain estimates of peak and off-peak prices. Table 3.1-16 provides the monthly on-peak and off-peak market price defined by Aurora, for the medium projection condition, for the two specific years of 2005 and 2010, in nominal prices and real 1998 dollars. The general trend over time of the market prices based on the marginal costs was towards the marginal costs associated with CC. This was expected because of the study assumption that all new resources would be CC. As the new CC plants become a larger share of the resource mix they are operated more and replace inefficient thermal plants as the marginal cost resource.

These prices are assumed to reflect normal market conditions in the future based on the long term market developments. Any examination of the market prices recently seen on the California exchange market will demonstrate fairly wide-swings in market prices at different times of the year. These price swings are expected in any real world market, but cannot be accurately forecasted with the long term modeling tools used in this analysis.

Table 3.1-16. Hydropower Analysis: Average Market-Clearing Prices From NPPC Study

Medium Projection Condition For Two Years (mills/kWh)

YEAR 2005

Month	On-Peak (Nominal $)	Off-Peak (Nominal $)	On-Peak (1998 $)	Off-Peak (1998 $)
Sep.	42.39	31.55	35.66	26.54
Oct.	32.32	28.60	27.19	24.06
Nov.	33.78	28.14	28.42	23.68
Dec.	37.58	32.81	31.62	27.60
Jan.	36.87	32.46	31.02	27.30
Feb.	34.63	29.97	29.13	25.21
Mar.	26.77	26.35	22.52	22.17
Apr.	25.95	20.02	21.83	16.84
May	20.05	18.17	16.87	15.29
June	24.37	17.59	20.50	14.80
July	32.10	25.32	27.00	21.30
Aug.	43.39	31.32	36.50	26.35
Avg.	32.52	26.86	27.36	22.60

YEAR 2010

Month	On-Peak (Nominal $)	Off-Peak (Nominal $)	On-Peak (1998 $)	Off-Peak (1998 $)
Sep.	54.40	32.79	40.45	24.38
Oct.	32.89	29.29	24.45	21.78
Nov.	36.13	31.01	26.87	23.06
Dec.	39.13	32.77	29.09	24.37
Jan.	37.78	35.20	28.09	26.18
Feb.	38.83	31.05	28.88	23.09
Mar.	36.58	27.14	27.20	20.18
Apr.	31.01	20.16	23.06	14.99
May	18.81	18.44	13.99	13.71
June	22.05	17.56	16.40	13.06
July	27.06	27.61	20.12	20.53
Aug.	41.35	39.91	30.74	29.67
Avg.	34.67	28.58	25.78	21.25

The average monthly prices for peak and non-peak were used to identify the economic effects associated with changes in hydropower generation. This was done by computing the change in hydropower generation from the current conditions, by subtracting the Pacific Northwest hydropower generation with each alternative from the base condition (Alternative 1, Existing Conditions). Adjustments were also made to the monthly hydropower generation by separating it into peak and non-peak hours based on the historic distribution shaping of the monthly hydropower generation. Table 3.1-4 presented the hydropower generation changes for each alternative based on average monthly generation. Table 3.1-17 multiplies the projected market price (from Table 3.1-16) by the changes in hydropower output from the base condition using both HYSSR and HYDROSIM outputs. This table labels the economic effects as net economic costs to represent changes from the base condition.

Table 3.1-18 provides the average annual net economic costs based on the market price analysis, by different discount rates, by the two hydroregulation models, and for the high, medium, and low economic forecast conditions. The values in this table were based on the differences from the base condition (Alternative 1, Existing Conditions). The results from the different hydroregulation models of HYDROSIM and HYSSR are not significantly different.

3.1.6.3 Reliability and Capacity Effects

This section describes how the changes in the hydropower capacity in the Pacific Northwest were investigated. Of particular interest is how will hydropower capacity reductions impact the generation reliability in the region and the WSCC in total, and to what extent additional thermal capacity will be built to replace losses in hydropower capacity.

To simplify the approach the reliability of the system is broken into two components for this examination: generation reliability and transmission reliability. This section concentrates on the reliability of the generation capacity of the system. The following section will address the impacts that different alternatives will have on transmission reliability. It was assumed here that transmission reliability will not be allowed to change from existing conditions for any of the alternatives, and the costs of maintaining this transmission reliability are presented in section 3.1.7.

Generation reliability can be evaluated numerous ways, but all approaches are generally based on how well the available generating resources can meet load in all time periods. In the Pacific Northwest the generation reliability of the power system primarily depends on the availability of water to generate hydropower. The scheduled and unscheduled (forced) outages of resources are also a significant component of any generation reliability analysis. The system power models used in the analysis account for the forced outages by either including random outages or de-rating the units. For example, the BPA model de-rates the new CC units by 5 percent to account for the probability of unscheduled outages and an additional 3 percent for the scheduled maintenance. The PROSYM model incorporates forced and maintenance outages on a plant by plant basis based on outages common to the different type of resources.

Traditionally, the Pacific Northwest generation reliability has been defined considering the dependable capacity of the hydropower system based on critical water conditions and high demand periods. This type of "firm planning" analysis has taken several forms over the years, all of which were geared towards assuring that loads are met with available generation with a high level of probability. However, as with other issues addressed in this appendix, the movement to a competitive electricity market affects how to analyze the issue of reliability and replacement capacity. With less regulation of the electrical industry and more independent power producers, many experts feel that market conditions

Table 3.1-17. Hydropower Analysis: Net Economic Costs Computed From Market Prices

HYDROSIM		
	Alternatives	
Year	**1 ($ million)**	**2 and 3 ($ million)**
2005	0	0
2006	0	0
2007	0	237
2008	(8)	227
2009	(8)	226
2010	(7)	223
2011	(7)	231
2012	(7)	226
2013	(7)	223
2014	(7)	222
2015	(7)	218
2016	(7)	222
2017	(7)	216
2018	(7)	216
2019 - 2104	(7)	216
Results:		
NPV at 0%	(698)	21,719
NPV at 4.75%	(148)	4,586
NPV at 6.875%	(104)	3,213
Avg Annual at 0%	(7)	217
Avg Annual at 4.75%	(7)	220
Avg Annual at 6.875%	(7)	221

HYSSR		
Year	**2 and 3 ($ million)**	**4 ($ million)**
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0
2007	0	228
2008	(10)	235
2009	(10)	230
2010	(10)	227
2011	(10)	227
2012	(10)	223
2013	(10)	226
2014	(9)	220
2015	(9)	220
2016	(9)	220
2017	(9)	220
2018	(9)	220
2019 – 2104	(9)	220
Results:		
NPV at 0%	(943)	22,109
NPV at 4.75%	(199)	4,672
NPV at 6.875%	(140)	3,274
Avg Annual at 0%	(9)	221
Avg Annual at 4.75%	(10)	224
Avg Annual at 6.875%	(10)	225

Note: Market clearing price multiplied by change in hydropower. Differences from Alternative 1, Existing Conditions. 1998 real million dollars, starting at in-service date. Medium condition projections.

Table 3.1-18. Hydropower Analysis: Average Annual Net Economic Costs From Market Prices

Average Annual Costs at Discount Rate 6.875%							
HYDROSIM & Aurora Prices ($)				HYSSR & Aurora Prices ($)			
Alternative	**Low**	**Med**	**High**	**Alternative**	**Low**	**Med**	**High**
2 and 3	(5)	(7)	(12)	2 and 3	(7)	(10)	(16)
4	151	221	347	4	154	225	353

Average Annual Costs at Discount Rate 4.75%							
HYDROSIM & Aurora Prices ($)				HYSSR & Aurora Prices ($)			
Alternative	**Low**	**Med**	**High**	**Alternative**	**Low**	**Med**	**High**
2 and 3	(5)	(7)	(12)	2 and 3	(7)	(10)	(16)
4	148	220	347	4	151	224	353

Average Annual Costs at Discount Rate 0%							
HYDROSIM & Aurora Prices ($)				HYSSR & Aurora Prices ($)			
Alternative	**Low**	**Med**	**High**	**Alternative**	**Low**	**Med**	**High**
2 and 3	(5)	(7)	(12)	2 and 3	(6)	(9)	(16)
4	141	217	346	4	143	221	353

Note: 1998 real million dollars, various in-service dates, 100-year analysis. All amounts are cost differences from Alternative 1, Existing Conditions.

will be the driving force to determine when new resources will be built. The expectation is that, in a competitive market, the decision to build new resources will be based on economic return rather than some regulatory convention. This assumption provided the conceptual basis for the reliability and replacement capacity portion of this appendix.

On a simplified basis the market driven capacity addition decisions will probably be based on the following considerations. The market-clearing price for any selected time period will generally be based on the marginal costs of the last resource. Only during periods of extremely high demand (peak demand), typically on very hot summer (or cold winter) days, when the demand for electricity approaches the available generating capacity, would prices rise above the marginal costs of the most expensive generator operating. Because the amount of capacity available at any point in time is fixed, and new generating capacity cannot be built quickly, the only way in which demand and supply could be kept in balance during extremely high demand periods would be through an increase in the price, to a level that would encourage some consumers to reduce their usage. The frequency of these periods of high prices will help determine whether new generating resources will be built. The price adjustment during periods of peak demand can be thought of as representing the value consumers place on reliability.

This price signaling concept and the frequency of occurrence formed the decision criteria for construction of new resources in the BPA and Aurora models used in this power analysis. With these models, new resources are assumed to be built when the marginal costs are sufficiently high and frequent to cover the cost of constructing the resource (in terms of the annualized fixed costs) and the variable operating costs. This economic justification approach was used in this study to estimate how many new resources would be built in each of the study alternatives, on a year-by-year basis from the present to year 2017. The additional fixed costs are included as a component of the total system production cost for identifying the net economic effects of each alternative. These costs are similar to the traditional capacity costs identified in past studies.

Several important elements of this generation reliability approach had to be considered by the study team. Of most interest in this analysis was, (1) the treatment of periods in which existing resources were insufficient to meet electricity load, and (2) consideration of system reserves requirements and dependable capacity.

Unserved Load and Demand-Side Resources. The model simulations of Pacific Northwest and WSCC systems identified time periods in which the projected load exceeded the amount of energy available to meet this load. When this situation occurred, the models reported this as unserved load and the number of megawatt hours in which this occurred was tabulated. In general the unserved load occurred in the model simulations during low water periods of the year, in low water years, and periods of high demand. How to treat this unserved load is a critical element of the generation reliability issue.

One approach considered for treating the unserved load in this analysis was to assume that a curtailment in energy provided will occur and the user will suffer the economic losses. The appropriate value to assign to this curtailment is not known, but in some studies it has been assigned a relatively high value that exceeds the marginal costs of all thermal resources. This approach was used in the PROSYM model.

The approach that was used with the Aurora and BPA models recognized that market prices will affect power demands, and included demand-side management measures as potential resources to address unserved loads. Instead of assuming curtailments will occur, the Aurora and BPA analyses assumed demand-side actions would be taken first to meet some of the peak demands. Section 3.1.5.3 described how the potential size of demand-side resources and their marginal costs were defined for this study. These resources were priced in blocks with each successive block being more costly. The demand-side resources were treated like any other resource in the dispatching routines. During periods of high demand when thermal and hydropower resources are nearing full dispatch, the models dispatch the blocks of demand-side resources as needed to meet load. The demand-side resources are considered in defining the marginal costs and production costs in the two models.

Since the demand-side resources are priced at relatively high levels, the extent to which they are dispatched will influence the optimizing routines and consequently help determine how many new resources would be built. The Aurora and BPA models utilized the demand-side resources in the dispatch routines and the optimizing routine for additional resources. Table 3.1-12 showed the amount of new thermal resources that were added by the BPA model for specific years of simulations, by alternative, and by the regions of the Pacific Northwest and Pacific Southwest. A sensitivity test was done by the study team to find out to what extent the pricing of the unserved load and demand-side resources influenced the amount of new generation capacity that would be built and the total system production costs.

As discussed above, the unserved load was met in the BPA and Aurora models by demand-side resources that were valued in blocks. The range of values (marginal costs) were from 50 to 500 mills/kWh depending on the size of unserved load. If any unserved load still occurred after dispatching all demand-side resources, it was assigned a marginal cost of 1,000 mills/kWh. To determine how significant these assumed block sizes and prices were, a test analysis was undertaken. In this test the BPA model was run by replacing all costs of demand-side resources and any unserved loads with a cost of 5,000 mills/kWh. As expected, with this higher cost for unserved load, more new resources were found to be economical and were added by the model. In the test case the amount of new CC resources built in year 2010 was 15,690 aMW in the Pacific Northwest and Pacific Southwest with Alternative 1, Existing Conditions, and 16,420 aMW with Alternative 4, Dam Breaching. This is an increase from the original analysis of 7,040 and 6,950 for Alternative 1, Existing Conditions, and Alternative 4, Dam Breaching, respectively.

The increase in the amount of new resources in the test case reflected that new resources could capture the high values to a large enough extent to economically justify their construction. The amount of new resource additions is not the only significant factor to examine. The total system production costs in the test and the original cases were also compared. The total system production costs with the test case increased significantly due to the costs of adding about 7,000 additional aMW of new CC capacity. However, the variable production costs, relative to the original case, dropped in the test case. The new CC resources (about 7,000 aMW in the test case) are more efficient and have lower variable costs than many of the existing resources in the resource mix. With more of these relatively efficient resources available for the model (in the test case) to dispatch to meet the load, the use of older resources with higher variable costs was reduced.

The changes in total system production costs between Alternative 1, Existing Conditions, and Alternative 4, Dam Breaching, under both cases yielded some interesting results. Generally, it was found that losing the lower Snake River powerplants in a system with lots of excess capacity is not as costly as losing the plants in the original case.

In conclusion, this test showed that the treatment of the value the unserved load in the model influences the amount of new thermal resources that are built by the model. Assigning a very high value to unserved load will result in more new CC capacity and substantial increases in the total system production costs (i.e., variable costs + fixed costs). However, the increase in fixed costs from adding more CCs are partially offset by reduced variable production costs. It was found that in both the test and original cases the total system production costs increased with the breaching of the lower Snake River dams. However, the valuing of unserved load did somewhat influence the magnitude of the total system production costs associated with breaching the dams. The significance of this influence appeared to be relatively small when compared to the substantial increase in the value of unserved load used in the test case. But, the study team decided to further examine the relationship of increasing fixed cost and reducing variable costs with capacity additions. The next section examines the significance of capacity additions to total system production costs.

System Reserves and Dependable Capacity Examination. As with any assessment of system reliability, criteria of acceptable reliability need to be devised and defined. Various criteria have been used historically in California and elsewhere in the West. These criteria have differed depending on the type of study, planning or operating, and the time period of the study. One measurement tool has been the planning reserve margin, which is expressed as a percentage of generation capability in excess of peak demand. The "correct" level of planning reserves in a deregulated market has yet to be established, and many argue that this level should be an economic decision made by market participants.[2/]

[2/] California Energy Commission, Karen Griffin, Memorandum 14 April 1998. Generation Reliability Study for ISO.

The type of criteria that may be developed in the future is hard to determine at this time. The WSCC has operated under a number of voluntary criteria and these reliability criteria are currently under examination for revision. Based on all these proposals and their uncertainty, any attempt at this time to specifically define a set of reliability criteria would be subject to criticism and would be likely to change before any of the lower Snake River alternatives could be implemented. For this reason, the study team examined the effects of different reliability criteria on the net economic effects. In particular the team looked at Alternative 4, Dam Breaching (changes from Alternative 1, Existing Conditions) with medium economic forecasts, in a specific year of 2010. Varying levels of additional new generating capacity were examined with the BPA and PROSYM models. The different amounts of new capacity resulted in different levels of system reserves (hence reliability) in the Pacific Northwest and different system production costs.

The amount of additional CC generation capacity assumed to be built by year 2010 under Alternative 4, Dam Breaching, was computed by the BPA model to be 890 MW as shown in Table 3.1-12. Higher and lower amounts of CC additions were examined. Utilizing the BPA model the several different levels of new capacity were modeled to see how total system production costs (variable costs + fixed costs of new resources) would change. In addition, a scenario in which no additional resources were added above those assumed to occur with Alternative 1, Existing Conditions was also tested.

Figure 3.1-4 shows the results from the BPA model for these different scenarios. The figure shows the variable costs (production costs), the fixed costs (new capacity costs), and the total costs (total system production costs). This figure also shows the capacity addition level in which total system production costs are at their minimum. It can be concluded from this figure that the addition of 890 MW (820 aMW) of new capacity is at or near the point of economic optimum (point of minimal net economic costs). This was expected because the BPA model utilized an optimization routine to define the 890 MW level. One interesting point from this figure is at around 2700 aMW of new additions the system variable costs go below zero. This means that if enough new CC plants are added to the system, with the breaching of lower Snake River dams, the system production costs (variable costs) will be less than if the dams were not breached. However, the fixed costs of these high level of capacity additions are so large that the total system production costs (variable + fixed) are much higher (about $300 million annually) than the base condition. The relatively flat slope of the total cost curve suggests that the selection of the most appropriate new capacity level may not be an extremely sensitive element of the hydropower study.

This same type of analysis was done with the PROSYM model. The PROSYM model provides the planning reserve margin for each of the transmission areas in the model. The planning reserve margin is the percent of generation capacity in excess of the highest peak load hour in the year. The planning reserve margins for all regions except the Pacific Northwest were the same for Alternative 1, Existing Conditions, and Alternative 4, Dam Breaching. Three different levels of new capacity were examined. The resulting planning reserves in the Pacific Northwest for year 2010 were estimated at 4 percent, 10 percent, and 12 percent for CC additions of 890 MW, 2640 MW, and 3250 MW, respectively.

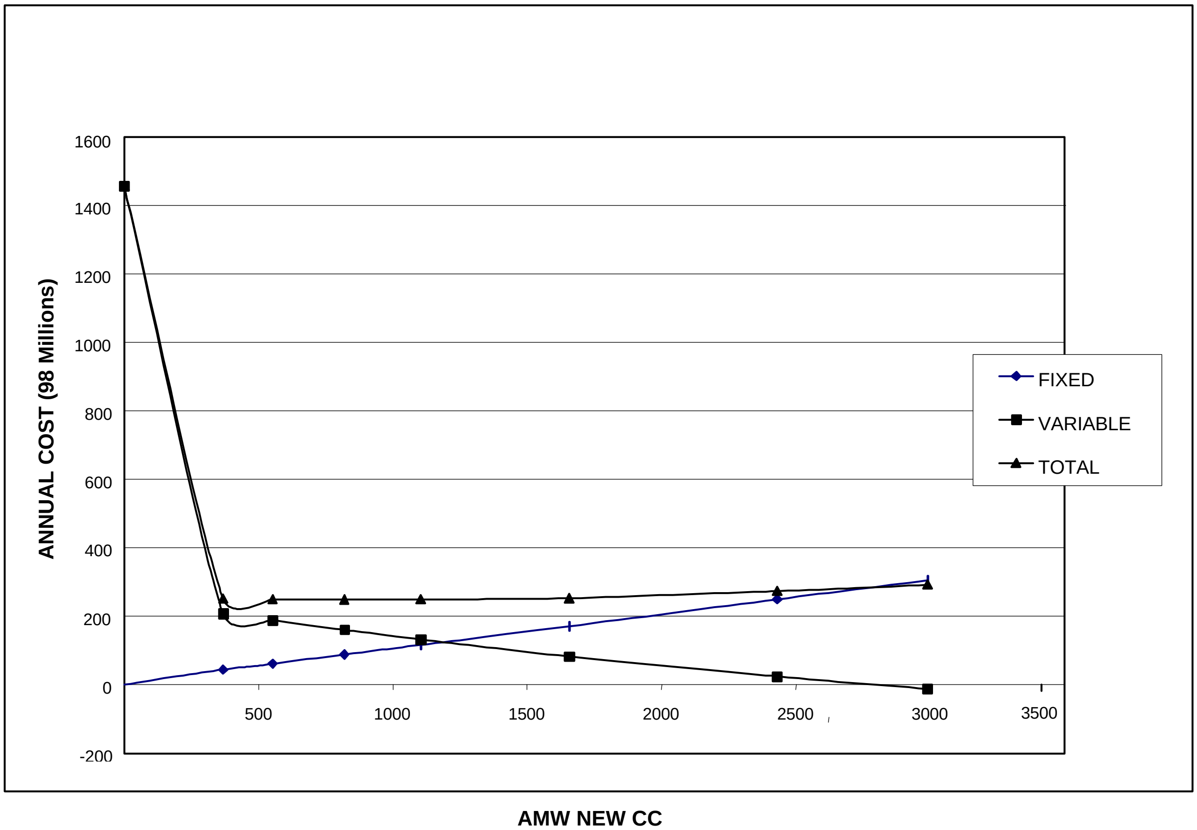

Figure 3.1-4. Total System Production Costs with Different Additions (YR 2010) Increases in A3 from A1 with BPA Model

Note: The dip in the curve at approximately 550 aMW is a software graphing anomaly — Actual minimum is at 820 aMW.

Reliability and Capacity Conclusions. This section presented the basic elements of the study dealing with additions of new generating capacity to replace the lost capacity associated with the breaching of the four lower Snake River dams. The replacement of the lost capacity relates to the general reliability of the power system over time and to what extent the market might pay for additional reliability. One complicating element of this hydropower analysis was the projection of what society might pick as the most appropriate reliability criteria in the study period of 2005 and beyond. The approach used in this study to estimate what level of new capacity would be built was to do an economic optimization to determine what level of new resources could be economically justified for construction. The study team, however, wanted to test the study results against other possible levels of new capacity and related generation reliability.

The study team was concerned whether different levels of replacement capacity and different approaches to the treatment of unserved loads would significantly change the estimates of increased system production costs. These two factors were tested with different approaches that lead to different levels on new capacity and planning reserve margins. With the higher levels of new generating capacity, the planning reserves were higher but so were the total system production costs. However, it was found that the total system production costs were not extremely sensitive (on a percentage basis) to different levels of assumed new generating capacity. So, the study team was satisfied that the capacity addition approach used in this analysis represented a reasonable estimate of the economic effects associated with the alternatives.

3.1.7 System Transmission Effects

The analysis of power system effects up to this point assumed that transmission reliability and service would remain the same under all alternatives. The purpose of this section is to identify the costs associated with maintaining transmission reliability with all the alternatives. This section investigates the impacts that Alternative 4, Dam Breaching, would have on the Northwest transmission grid. Alternative 2, Maximum Transport of Salmon and Alternative 3, Major system Improvements are not expected to have any significant impact to the transmission grid.

Alternative 4, Dam Breaching would breach the four lower Snake River dams, rendering the powerhouses inoperable, and thereby altering the source of power generation that feeds into the Northwest transmission grid. Since the transmission grid was originally constructed in combination with the generation system and since they interact electrically, loss of generation would affect the transmission system's ability to move bulk power and serve regional loads.

The transmission analysis looked at transmission system impacts with and without replacement generation. Both transmission system reinforcements and generation additions were evaluated to mitigate the transmission system impacts caused by breaching the four lower Snake River dams. The initial phase of this transmission study assumed no replacement generation for the dams that are breached. The transmission improvements needed to maintain reliable service were then identified and costs estimates were prepared. However, it was recognized that the construction and location of replacement generating resources would have a profound effect on the transmission system impacts and reinforcement needs and may provide a most cost-effective solution. This phase of the study was done separately from the energy supply additions shown in Table 3.1-12. The energy supply studies indicated that Alternative 4, Dam Breaching would require 890 MW of new CC generation in 2010 to replace lost hydropower. This transmission study evaluated transmission system requirements if replacement generation were constructed in a location where it would provide transmission system benefits to mitigate the loss of hydropower. To the extent that more than 890 MW of new CC generation will be required for transmission reliability, the additional costs are added to the transmission impacts.

Preliminary cost estimates for capital additions are included in this summary. These costs are based on preliminary studies using typical costs for facilities. A range of cost is given since there is much uncertainty about the scope of the projects, routes, etc., which could affect project cost.

Transmission impacts were examined for two seasonal conditions, the summer and the winter peak situations. The following defines the expected impacts and the possible solutions. The study approach was to first identify the impact to the transmission system, then the possible solutions were examined. The final step of the analysis was to select the most cost-effective measure to address the identified transmission impact.

3.1.7.1 Summer Impacts

The summertime peaks are the largest in the Pacific Southwest and transmission from the Pacific Northwest over the California-Oregon Intertie/Pacific Direct Current Intertie (COI/PDCI) is important to meeting the Pacific Southwest demands.

Northwest to California Transfers

If the lower Snake River dams were breached and not replaced, the COI/PDCI transfers limits would decrease by 200 MW (from 7200 to 7000 MW). This would limit the ability to sell and transfer Pacific Northwest generation to the Pacific Southwest to meet peak demands. Three possible solutions were postulated: 1) Reduce the COI/PDCI capacity by 200 MW and incur losses in sales. The economic costs of this approach were not quantified. 2) Upgrade the COI/PDCI intertie to maintain its capacity at a cost of $65 million to $85 million. 3) Site thermal replacement plants in the locations that would reinforce intertie transfer capabilities. Further study of summer solutions to the Pacific Northwest to California impacts was not done since it was realized that the solutions to the summer impacts may be unnecessary because the solutions to the winter problems could also correct the summer impacts.

Northwest Regional Impacts

With the breaching of the four lower Snake River dams, there would be more stress on the transfer capability in the upper mid-Columbia area. Two transmission system cutplanes, north of John Day and north of Hanford, would be impacted. (A cutplane is a group of transmission lines whose total loading is an indicator of system stress.) These particular cutplanes measure how much power is flowing from the Upper and Mid Columbia area to COI/PDCI. With the elimination of generation from the lower Snake River facilities and a desire to have the same level of north to south transfers on the COI/PDCI, the flow across the cutplanes would need to increase. In other words, the generation from the lower Snake River facilities would be replaced with generation from Chief Joseph, Grand Coulee, and other northern and eastern powerplants. However, with this increase in generation, capacities across these cutplanes would be exceeded. Thus, the cutplane flows would need to be limited, which in turn would cause a reduction in the COI/PDCI transfer capability. To increase cutplane capability an improvement to the Schulz-Hanford transmission line and facilities would be required. The estimated costs are $50 to $75 million.

Montana to Northwest Transfer Capability

Capability west of Hatwai would be reduced about 500 MW if the lower Snake River dams were breached. This means that transfers from Montana and/or Western Montana Hydro would need to be reduced to maintain the Hatwai limit. Previous studies have shown that these problems would be mitigated with a Bell-Ashe 500-kilovolt (kV) line from Spokane to the Tri-Cities area. This line would require a new transmission corridor and cost between $100 million to $150 million.

Summer Load Service

The Tri-Cities load area (south of Spokane and Central Washington) would be negatively affected by dam breaching. Specific transmission impacts would be different depending on the location of replacement generation. These include the new Schultz-Hanford line ($50 to $75 million) and reconductoring or rebuilding various other lower voltage lines at an estimated cost of $10 to 20 million. Additional voltage support would also be needed in the Tri Cities area if the four lower Snake River dams were breached. Converting the generators at a hydropower plant to synchronous condensers would be an effective way to produce reactive support required to fix this voltage support problem for Tri-Cities area loads. This could be accomplished with converting the generators at Ice Harbor. Preliminary cost estimates for this conversion are $2 to $6 million.

3.1.7.2 Winter Impacts

The impacts to the transmission system under extreme winter load conditions in the Pacific Northwest were examined. An extreme cold winter load condition was examined since stress on the system is high under extreme weather. The extreme cold winter load level is an abnormal cold condition (arctic express) with minimum temperatures that have a 5 percent probability of occurring. The extreme cold winter load level is approximately 12 percent higher than the expected normal winter peak that has a 50 percent probability of occurring. This is the criteria BPA customers have agreed to in the past.

It was found that imports from the California interties could not meet the shortfall created by the loss of the lower Snake River dams. The import capability today on the COI/PDCI with the dams in place is around 2,400 MW during extreme winter load conditions. This 2,400 MW capability is needed today, with the four lower Snake River dams in place, to augment available generation and spinning reserve requirements in the Pacific Northwest. Without the four lower Snake River dams, either more intertie or more local generation would be required to meet system loads and maintain system reliability. The possible solutions examined were to develop replacement generation or to improve the COI/PDCI. The analysis shows that replacement generation would be about half as costly as intertie transmission improvements.

Pacific Northwest Replacement Generation

With the breaching of the lower Snake River dams it was found that 1,550 MW of new generating resources (replacement generation) strategically located in the Pacific Northwest would be sufficient to meet the winter extreme conditions if the COI/PDCI were not improved. This is about 510 MW more replacement generation than would be required for energy alone.

The new capacity assumed to be built in the future to replace energy lost under Alternative 4, Dam Breaching, was described in Table 3.1-12. The net economic costs identified in this technical report for Alternative 4, Dam Breaching, were based on adding 890 MW of new Pacific Northwest generating resources by year 2010 and 1,040 MW by year 2018. But this takes care of only regional energy losses at the breached dams. The winter transmission impacts of breaching could be mitigated if 1,550 MW of replacement generating resources were in place at the time of breaching of the lower Snake River dams (2007). The transmission system impacts of breaching would require more generation in place sooner (1,550 MW in 2006 versus 890 MW in 2010 and 1,040 in 2018).

The costs of providing additional replacement generation were examined using the system production cost approach as computed by the BPA model. The replacement capacity assumed to be built elsewhere in this analysis was 1,040 MW through year 2018 as shown in Table 3.1-12. To maintain the same transmission reliability an additional 510 MW (1,550 – 1,040) of generation capacity would need to be constructed in Pacific Northwest. Based on the CC construction costs of $601,000 per MW, the additional construction costs of replacement thermal would be about $306 million. These increased costs will be somewhat offset by the expected reduction in system variable costs from adding more generation than is required for energy alone. The annual equivalent economic costs associated with the additional generation capacity are $8.9 million at the 6.875 percent discount rate.

Improvements to COI/PDCI

The alternative solution to building new replacement capacity is intertie transmission system reinforcements. The improvements needed to meet load service requirements for extreme winter conditions include: a second Captain Jack-Meridian 500-kV line (a cross-Cascades line from Klamath Falls to Medford) and a second Big Eddy-Ostrander 500-kV line (a cross-Cascades line from The Dalles to Portland. Both of these new line additions would need to be on a separate right of way from the existing lines due to reliability reasons. The construction costs for a second Captain Jack Meridian line are estimated at $80 to $130 million. The addition of a second Big Eddy-Ostrander line would cost from $70 to $120 million. The average annual costs of these two lines, considering O&M, replacements, repair, and computed at 6.875 percent, were $5.6 to $9.0 million for Captain Jack Meridian and $4.9 to $8.3 million for Big Eddy-Ostrander. The mitigation costs of the transmission solution would be about twice as expensive as the generation solution.

Winter Local Load Service Limitations

There would also be wintertime load service limitations in the Tri-Cities area for extreme cold winter conditions if the lower Snake River dams were breached. A new 230/115-kV transformer in the Franklin area would be required. The estimated cost for adding this transformer is between $15 million and $25 million.

3.1.7.3 Summary of Transmission Impacts

Table 3.1-19 provides the possible solutions and related annual costs based on the 6.875 percent discount rate. The table is broken into the impact areas and possible solutions. For each impact the lowest cost solution is recommended and included in the total economic effects.

Table 3.1-19 shows the range of construction costs as estimated by BPA. Also shown are the incremental O&M costs that would occur if the transmission improvements were built. To develop the annual costs associated with these measures a 45-year replacement cycle was assumed. As can be seen from this table the annual costs associated with improvements needed to maintain transmission reliability with the breaching of the four lower Snake River dams would about $22 to $28 million at 6.875 percent.

Identical summaries were made at 4.75 percent and 0.0 percent discounts rates. The annual costs were $19 to $24 million at 4.75 percent and $16 to $18 million at 0 percent discount rates.

3.1.8 Ancillary Services Effects

This section discusses the ancillary services and the estimated economic values of these services provided by the four lower Snake River facilities. These ancillary services are in addition to the energy, capacity, and transmission support benefits discussed elsewhere in this appendix. With the open access transmission ruling of the FERC, power suppliers are now charging for many of the ancillary services that in the past were generally provided without charge by the entities owning the transmission facilities. In 1998 BPA began to sell these ancillary services. Since these services are a necessary element of a safe and reliability power system, the loss of these services represents economic costs that must be accounted in this analysis.

The basis for the reserve cost and Automatic Generation Control (AGC) assumptions associated with dam breaching were largely based on expert judgement from knowledgeable staff at BPA. The Duty Scheduling office was consulted for the seasonal MW amounts for which the lower Snake River plants are currently relied upon. For simplification it was assumed that this usage would continue into the future, and no effort was made to determine the absolute capability of the lower Snake facilities to provide AGC or operating reserves. Should the restrictions on the Columbia River hydropower projects increase relative to the lower Snake River facilities it is quite likely that the MWs of AGC and operating reserves from the lower Snake River facilities would increase. The converse is also true, but to a lesser degree since the lower Snake River facilities are generally low priorities for ancillary services in the current operating environment. The ancillary service prices were developed using Trading Floor knowledge of the bilateral market for Ancillary Services in the Northwest and market data from the California Independent System Operator (ISO) that was available at the time of the report.

The lower Snake River hydropower plants are used for Automatic Generation Control (AGC). Small but very frequent changes in generation are necessary to perform this function. Hydroelectric facilities, with stored water as their fuel, are extremely flexible and very useful for this purpose. If the four dams were breached, their contribution to this system would have to be spread over the remaining projects or replaced from other sources. To value the AGC, the BPA staff that deals with market sales of ancillary services was consulted. The economic value of AGC that would be lost with the breaching of the lower Snake River dams was based on the percent of time that AGC is utilized, the MW magnitude, and the market value. The average annual value was estimated to be $465,000.

The four lower Snake River dams are also used to provide part of the required reserves for the Federal power system. The WSCC has established reserve requirements for all utilities. These contingency reserves are expected to be “on-call” in the event of emergency loss of generating resources in the system. Utilities are required to have both operating and spinning reserves. The spinning reserve units must be synchronized with the power system and provide immediate response, while the operating reserves must be available within 10 minutes. BPA estimates that the Snake River facilities are used for reserves for about one half of the months of December and March and all of the months of January, February, April, May, and June. BPA relies on about 300 MW of reserves from these four facilities. The market values of these reserve services vary throughout the year. In the high demand winter months it was assumed that BPA would have to purchase reserves from the market at a value of $31/MW-month. During the rest of the year it was assumed BPA would sell this reserve at the average monthly market prices. The annual net economic cost associated with the loss of these reserves is estimated to be $7,183,000.

The total ancillary annual losses for Alternative 4, Dam Breaching are the combination of the AGC loss in Table 3.1-20 and the loss of reserve value in Table 3.1-21. This loss is $7,648,000, annually. This was rounded to $8 million for reporting purposes in the rest of this document.

Table 3.1-19. Hydropower Analysis: Transmission Impacts With Alternative 4, Dam Breaching

Annual Values Based on 6.875%

Timing/ Location of Impacts	Impact Description	Possible Solutions	Estimated Construction Costs ($millions)	Incremental O&M Costs ($millions)	Total Annual Costs ($millions)	Selected Solution Avg. Annual Costs ($millions)
Summer: NW to California	Transfer limit is reduced (a cutplane problem)	Limit COI/PDCI transfer capability from 7200 MW to 7000 MW	Not qualified			
		Upgrade the COI/PDCI	65 to 85	0.3	5.1 to 5.9	
		Site thermal replacement plants to reduce impact	Not quantified			Proper siting 1550 MW for winter could solve this problem
Summer: Upper/Mid Columbia Load Service	Thermal overloads	New Schultz-Hanford transmission line	50 to 75	0.17	3.6 to 5.2	3.6 to 5.2
Summer Tri-Cities Service	Voltage support to the Tri-Cities	Ice Harbor generators converted to synchronous condensers	2 to 6	0.2	0.4 to 0.6	0.4 to 0.6
	Load service impacted	Local line transmission improvements	10 to 20	0	0.7 to 1.4	0.7 to 1.4
Summer: Montana transfer to Northwest	Transfer limit is reduced by 500 MW	New Bell-Ashe transmission line	100 to 150	0.38	7.2 to 10.5	7.2 to 10.5
Summer: Canada Transfer to Northwest	Increased congestion on I-5 transmission corridor	No solution offered	Not quantified			

Table 3.1-19. Hydropower Analysis: Transmission Impacts With Alternative 4, Dam Breaching, Continued

Annual Values Based on 6.875%

Timing/ Location of Impacts	Impact Description	Possible Solutions	Estimated Construction Costs ($millions)	Incremental O&M Costs ($millions)	Total Annual Costs ($millions)	Selected Solution Avg. Annual Costs ($millions)
Winter: Meeting extreme winter loads	Import capability is reduced and results in inability to meet extreme loads	Site 1550 MW of replacement generation	306 capital costs for generation	Included in annual costs	8.9	8.9
		New transmission lines – Capt. Jack – Meridian and – Big Eddy – Ostrander	80 to 130 70 to 120	0.2 0.2	5.6 to 9.0 4.9 to 8.3	
Winter: Tri-Cities Load Service	Load Service Limitations	Local transmission improvements McNary - Franklin	15 to 20	0.1	1.1 to 1.5	1.1 to 1.5
Totals [1/]			483 to 577			21.9 to 28.1

1/ Includes only costs for selected solutions.

3.1.9 Summary of Hydropower Net Economic Effects

This section combines all the net economic effects as defined by the medium projection conditions. These represent the most likely point estimates of economic effects. However, because of the uncertainty embedded into many of the key variables, a risk and uncertainty analysis was undertaken to provide range of results.

With Alternative 4, Dam Breaching, there would be some savings to the nation because it would no longer incur the costs to operate these dams. This section does not include the savings in operation and maintenance costs that will occur with this alternative. These savings are included in the Avoided Cost category which is discussed in section 3.8.5 and including them here would have resulted in double-counting these costs.

Table 3.1-20. Automatic Generation Control Losses

Month	Hours Per Month	MW Provided	Percent of Time (%)	Value Per Hour (1998 Real $)	Monthly Value ($)
Jan	744	30	20	9.50	42,408
Feb	672	30	20	9.50	38,304
Mar	744	30	20	8.50	37,944
Apr	720	30	20	5.00	21,600
May	744	30	20	5.00	22,320
Jun	720	30	20	6.50	28,080
Jul	744	30	20	9.50	42,408
Aug	744	30	20	16.50	73,656
Sep	720	30	20	11.50	49,680
Oct	744	30	20	6.50	29,016
Nov	720	30	20	8.50	36,720
Dec	744	30	20	9.50	42,408
Annual (Rounded)	8760	30	20		465,000

Table 3.1-21. Lost Annual Reserve Values

Month	Heavy Load Hours	MW Provided	Purchase Percent of time (%)	Market Sale Percent of time (%)	Purchase Cost (1998 Real $)	Market Value Per Hour (1998 Real $)	Monthly Value ($)
Dec 1/2	24	300	25	75	31.00	8.00	1,023,000
Jan	49	300	25	75	31.00	8.00	2,046,000
Feb	44	300	25	75	31.00	8.00	1,848,000
Mar 1/2	24	300	0	100	31.00	7.00	520,800
Apr	48	300	0	100	31.00	3.50	504,000
May	49	300	0	100	31.00	3.50	520,800
Jun	48	300	0	100	31.00	5.00	720,000
Annual (Rounded)	2,648	300					7,183,000

Table 3.1-22 presents the medium results for the two key approaches used to identify the net increases in costs to the power system as compared to the base condition. The costs in the table are the average annual equivalents with different discount rates. The two approaches used in the study were the system production costs and the market pricing approach. Different estimates of net economic costs were made by each of these approaches and models. But, the range of results from minimum to maximum is relatively small. The range is also relatively small over the three discount rates. For example, the annual net costs for Alternative 4, Dam Breaching, at 6-7/8 percent is from $220 to $226 million. The results for this alternative range from $216 to $226 million over all three discount rates.

The costs shown in Table 3.1-22 do not include the costs that would be incurred to maintain the same degree of reliability in the transmission system and the values for the loss of ancillary services. As shown in Tables 3.1-19, the region will have to build additional facilities at an average annual cost of $21.9 to $28.1 million (at 6.875 percent), $19.4 to $24.2 million (at 4.75 percent), and $15.6 to $17.9 million (at 0.0 percent). The ancillary services lost with Alternative 4, Dam Breaching, were estimated in section 3.1.8 as $8 million per year. Table 3.1-23 presents the total range of effects with the medium forecast conditions at the three different discount rates.

In summary, it can be seen from Table 3.1-23 that the total economic effects associated with changes in hydropower production with the different lower Snake River alternatives cover a wide range. With Alternative 2, Maximum Transport of Salmon, and Alternative 3, Major System Improvements, the net economic costs are negative, which is actually a benefit to the nation. The total net economic costs for these two alternatives range from -$7 million to -$10 million, annually, at the 6.875 percent discount rate. The range of net economic costs is larger for Alternative 4, Dam Breaching, and represent a loss to the nation. The net economic costs for Alternative 4, Dam Breaching, range from $251 million to $291 million, annually, at the 6.875 percent discount rate.

Table 3.1-22. Hydropower Analysis: Summary of System Costs (Production Costs and Market Prices)

		Discount Rate 6.875%			
Alternative	**Production Costs**	**Market Price**		**Range of Costs:**	
	BPA Model	**HYDROSIM**	**HYSSR**	**Minimum**	**Maximum**
2 and 3	(9)	(7)	(10)	(10)	(7)
4	255	221	225	221	255
		Discount Rate 4.75%			
Alternative	**Production Costs**	**Market Price**		**Range of Costs:**	
	BPA Model	**HYDROSIM**	**HYSSR**	**Minimum**	**Maximum**
2 and 3	(9)	(7)	(10)	(10)	(7)
4	256	220	224	220	256
		Discount Rate 0%			
Alternative	**Production Costs**	**Market Price**		**Range of Costs:**	
	BPA Model	**HYDROSIM**	**HYSSR**	**Minimum**	**Maximum**
2 and 3	(9)	(7)	(9)	(9)	(7)
4	260	217	221	217	260

Note: Cost differences from Alternative 1, Existing Conditions. Medium projections, 1998 $ million, average of all water conditions. Various in-service dates, 100-year analysis.

Table 3.1-23. Hydropower Analysis: Total Average Annual Net Economic Effects Differences from Alternative 1, Existing Conditions

Alternative	System Costs ($) Minimum	System Costs ($) Maximum	Transmission Reliability Costs ($) Minimum	Transmission Reliability Costs ($) Maximum	Ancillary Services Costs ($)	Total Effects ($) Minimum	Total Effects ($) Maximum
Discount Rate 6.875%							
2 and 3	(10)	(7)	0	0	0	(10)	(7)
4	221	255	22	28	8	251	291
Discount Rate 4.75%							
2 and 3	(10)	(7)	0	0	0	(10)	(7)
4	220	256	19	24	8	247	288
Discount Rate 0%							
2 and 3	(9)	(7)	0	0	0	(9)	(7)
4	217	260	16	18	8	241	286

Note: Medium projections, 1998 $ million, average of all water conditions. Various in-service dates, 100-year analysis.

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3.2 Recreation Use

An important aspect of this economic analysis is the evaluation of outdoor recreation associated with the lower Snake River. The economic values associated with recreation can be separated into direct and indirect economic values. Direct values represent the recreator's willingness to pay for activity. This is measured in two ways: (1) the costs to participate (e.g., the entrance fee); and (2) the dollar amount that the visitor is willing to pay above the out-of-pocket costs — the consumer surplus. Indirect values measure the effects on local economies associated with recreation-related expenditures. The economies of communities located near recreation use areas may depend directly on the number of visitors and the amount of money they spend in the area. Recreation-related expenditures include lodging and food, as well as automobile, boat, fishing, and hunting supplies. This section discusses the results of the analysis used to estimate the direct economic effects of the proposed alternatives in terms of expected recreation activities and the economic value of these activities. Indirect economic effects associated with recreation activities are evaluated in Section 6, Regional Economic Analysis.

3.2.1 Methods

A measure of the direct economic value of goods and services, including recreation activity, is the willingness-to-pay (WTP) of the users. For goods that are sold in a market, the WTP is the amount actually paid to obtain the good plus an additional amount that an individual would have been willing to pay for the chosen quantity of the good. This additional amount is generally referred to as the consumer surplus and represents the value of the quantity of the goods over and above the amount actually paid. Increases in consumer surplus are considered as welfare gains to the consumer because this extra value is obtained without charge. Total consumer welfare to society is measured by summing the consumer surplus across all participants. In the case of valuing recreation, the amount charged for the activity is generally small or non-existent. Since there is no well-established market for the exchange of recreation goods, non-market approaches have to be employed to develop demand curves to estimate consumer surplus.

3.2.1.1 Techniques Used to Measure Visitor Benefits

The structure of this analysis is based on the WRC guidelines (WRC, 1993). These guidelines recommend that either the Travel Cost Method (TCM) or the Contingent Valuation Method (CVM) be used to quantify visitors' net WTP. Both of these methods are used by other Federal agencies and are frequently used by economists (Loomis and Walsh, 1997). In this study, TCM is applied to estimate net WTP for the current reservoir recreation, river recreation above Lewiston, Idaho, and in recreation the Snake River basin in central Idaho. TCM uses the actual number of trips taken by an individual as the quantity variable and the visitor's travel cost as the price variable to trace out a statistical demand curve for recreation using multiple regression. The net WTP is calculated from this demand curve. See AEI (1999a, 1999b, 1999c) for more details on the TCM demand models used.

Since natural river conditions do not exist in the lower Snake River, one cannot survey existing users and directly apply a standard TCM to estimate the value of river recreation with dam removal. Therefore, a hybrid TCM approach, known as "contingent behavior" (CB), is used to estimate the value of river recreation under Alternative 4, Dam Breaching. This hybrid approach involves (a) describing the new recreation conditions, e.g., natural river scenario; (b) asking whether individuals would visit and, if so, how many times per year; (c) and calculating the distance, travel cost, and travel time to the most likely spot on the river they would visit. Thus, the variables are similar to those used in the TCM for current reservoir recreation. The same general recreation evaluation approach is applied to the data for all alternatives. The contingent behavior approach is widely used in economics, was applied in the Columbia River System Operation Review (SOR) (Callaway, et al., 1995) and has proved to be reliable (Loomis, 1993). A discussion of the contingent behavior TCM is provided in the Drawdown Regional Economic Workgroup (DREW) Recreation Workgroup report (DREW Recreation Workgroup, 1999).

3.2.2 Surveys and Findings

Five recreation use surveys were conducted as part of this study by the DREW Recreation Workgroup. Four of these surveys were designed to identify and value current recreation use. These surveys targeted different stretches of the river and different types of recreation activity. Two separate surveys, an angler survey and a general recreation survey, were mailed to a sample of recreationists who visited the lower Snake River reservoirs from May to October 1997. A survey was also mailed to a sample of anglers who fished the 30-mile stretch of the Snake River above Lewiston, Idaho from September 1997 to March 1998. An angler survey was also distributed to anglers in Central Idaho. The findings of these surveys are summarized in Table 3.2-1 and briefly discussed in the following sections.

Table 3.2-1. Existing Recreation Surveys, Number of Trips, and Annual Benefits

Survey	Number of Completed Surveys	Response Rate (%)	Number of Trips 1/	Willingness-to-Pay per Trip 1/	Annual Benefits (000s of dollars)
Reservoir Angler 2/	537	59	57,388	29.23	1,676
Reservoir General Recreation (excludes Angling) 3/	408	65	442,834	71.31	31,578
Upriver Angler 4/	247	72	11,437	35.71	408
Central Idaho Angling 5/	257	na	129,026	37.68	4,862
Total	**1,449**	**na**	**640,685**	**na**	**38,524**

1/ The number of trips and the willingness-to-pay per trip were estimated based on each survey. The surveys asked how many trips each individual takes a year and how much each trip costs. This travel cost is used to compute an individual's willingness to pay for recreation. Annual benefits are calculated by multiplying the number of trips by the willingness to pay per trip.

2/ Reservoir Angler Survey: Two separate travel cost method mail survey instruments were developed, an angler survey and a general recreation survey.

3/ Reservoir General Recreation Survey: A stratified sample of households received an eight-page survey.

4/ Upriver Angler Survey: Anglers surveyed were generally fishing for steelhead in the 30-mile stretch of the Snake River, above the town of Lewiston, Idaho.

5/ Central Idaho Angling Survey: Surveys were distributed to anglers and rafters at a variety of points by using on-site contacts and guides.

Source: DREW Recreation Workgroup, 1999.

The DREW Recreation Workgroup also surveyed a much larger sample of Washington, Idaho, Oregon, western Montana, and California residents to identify the type and number of recreation users that would visit the lower Snake River if the dams were breached. A stratified sample of households was mailed an eight-page survey. The sample region was based on an evaluation of the origin of current visitors to the Snake River and guidance provided by DREW. A total of 4,780 completed surveys were returned for a response rate of 54 percent. Only a portion of the 4,780 households returning surveys indicated they would visit the lower Snake River in its natural river condition. A copy of this survey instrument is presented in the DREW Recreation Workgroup report. The survey findings were then applied to all Washington, Idaho, Oregon, western Montana, and California residents. Response rates varied by region. The response rate in the area surrounding the lower Snake River was 56 percent, while the response rate for California was just 28 percent. Two of the natural river visitor use estimates adjust for these response rates when generalizing from the sample to the population to minimize any sample selection bias in the visitor use estimate.

The survey instrument was constructed to determine which types of recreation users would visit the area under a drawdown scenario. The survey further asked the visitors how many times per year those recreation visitors would visit the site. The Corps believes that because responses of one visit per year or more for some of the distant travelers does not appear reasonable, the survey may bias the results and over estimate usage. Those individuals coming from outside the region may not visit annually. Individuals from outside the region may only visit once every 5 years, or once every 10 years or once in a lifetime. Therefore, the Corps believes this may tend to over-estimate the recreation usage estimates of those from outside the region. This may be considered an unresolved issue at this time.

3.2.2.1 Lower Snake River Reservoir

The average net WTP per trip of reservoir fishing was $29.23 (many of these are very short trips of a day or less). Using information on angler hours per day and angler days per year from the Normandeau et al., survey, it is estimated 2,831 anglers took 57,338 angler trips during 1997. Multiplying the value per trip times the estimated number of trips yields annual benefits of $1.676 million in 1997.

The average net WTP or net benefit per day of non-angling reservoir recreation such as boating and waterskiing was $71.31 per trip. Corps visitation data are used to estimate the total number of hours. Subtracting the estimate of angler hours obtained from the Normandeau et al. data yields hours of reservoir recreation. Using the AEI survey data on average length of stay allows an estimate of days, which can be converted to trips. Annual recreation benefits are calculated by multiplying the value per trip times an estimated 442,834 trips yields an annual recreation benefit of $31.578 million. Details of the per-trip and annual TCM benefits methodology for general reservoir recreation analyses can be found in AEI (1999a), while the reservoir fishing is detailed in Normandeau, et al. (1999).

These benefits per trip can be compared to the benefit estimate recreation travel cost method demand model used to evaluate Lower Granite Reservoir recreation for the SOR study. Callaway et al. (1995) estimated an average consumer surplus of $32.74 per day. This value is greater than the reservoir angling estimate, but lower than the general reservoir recreation value, even when adjusted to a per trip basis.

3.2.2.2 Upriver of Lewiston, Idaho

The average net WTP for anglers fishing in the 30-mile stretch of the Snake River above Lewiston, Idaho is $35.71 per trip. Angler use estimates were made using a combination of aerial surveys, ground-based counts, and the visitor intercept surveys. Multiplying the benefit per trip times the resulting estimate of 11,437 angler trips yields an annual value of $408,408. Details of the per trip and annual benefits of this upriver angler analysis can be found in Normandeau et al. (1999).

3.2.2.3 Central Idaho

Anglers in Central Idaho (Snake River Basin) had an average net WTP per trip of $37.68. This yields an annual benefit of $4,861,700 when multiplied by an estimated 129,026 steelhead trips (see AEI, 1999b). The average net WTP per trip for non-angling upriver recreation such as rafting is $87.24. Using survey data information, the estimated use is 180,000 non-angler visitors to the region (AEI, 1999c). It is estimated these visitors take 497,480 trips annually. Multiplying the trip value times the estimated number of trips yields an annual value of $43,400,000.

3.2.2.4 Natural River General Recreation

Using the contingent behavior TCM, the value per trip of salmon and steelhead fishing in what would be the free-flowing lower Snake River if the dams are breached has an estimated value of $256 per trip of 3.36 days or $76 per day. The value for mainstem free-flowing river recreation activities such as rafting, canoeing, kayaking, and swimming, as well as river-related recreation, is estimated at $297 per trip of 2.6 days using survey respondents' reported trip cost (this is consistent with how the mainstem river anadromous fishing TCM benefits are calculated above). In the tables and analysis below, this river recreation value of $114 per day is considered the high NED value. Using a definition of the cost-per-mile price variable in the TCM demand function consistent with AEI (1999a), reservoir recreation yields a value of $71.36 per trip of 2.6 days. This resulting value per day is more consistent with the literature on the value of non-boating types of river-related recreation activities respondents indicated in the survey. A similar definition of the price variable consistent with AEI (1999a) reservoir angler travel cost per mile is used with the contingent behavior TCM to estimate the value of salmon fishing in the reservoirs ($39 per day) with the non-drawdown alternatives. For the mainstem river anadromous fishing, this $39 per day is considered the low NED value, while the $76 per day is considered the high NED value. The high NED value is more consistent with the value of salmon and steelhead river fishing in the literature than in Walsh et al. (1992).

Four estimates of river recreation demand and benefits are provided. They range from a low estimate (using just households that indicated they would definitely visit with dam breaching and assuming zero visitation from survey non-respondents) to a high estimate based on households that indicated they definitely *or* probably would visit and assuming that survey non-respondents would visit at the same rate as survey respondents. Middle use estimates of demand are provided by assuming that households that did not respond to the survey would visit at the same rate as households that did respond to the survey, but applying this assumption only to the fraction of the population that would definitely visit. A middle-high demand estimate consists of households that indicated they definitely *or* probably would visit, but assumes that survey non-respondents would not visit. Thus both the low and middle-high estimates explicitly adjust for potential concerns over low response rates from more distant areas by using zero visits for non-respondents. This yields a very conservative low and middle-high visitor estimate. Alternatively, the middle- and high-use estimates are not corrected for sample selection effects and they may yield over-estimates of recreation use.

These demand estimates are also phased in over time as the natural river system recovers from dam breaching. Table 3.2-2 presents the expected suitability of the area for river recreation with dam breaching. This table was initially developed by recreation planners at the Corps and then refined and applied to the dam breaching survey data. As can be seen in this table, some activities recover slower than others. For example, river and shorebased recreation takes up to two decades to fully recover.

Table 3.2-2. Recreation Suitability Recovery after Dam Breaching

Activity	Year 1	Year 5	Year 10	Year 20
Jet Boating and Jet Skiing	0.2	0.5	0.7	1
Rafting/Kayaking/Canoeing	0.3	0.5	0.8	1
Swimming	0.2	0.4	1	1
Picnicking and Primitive Camping	0.8	1	1	1
Developed Camping	0.6	0.9	1	1
Hiking and Mountain Biking	0.8	1	1	1
Hunting	0.5	0.8	1	1

Further, the demand estimates are compared to availability of developed campgrounds, dispersed camping areas, and boat-ramp capacity to determine how much of the demand can be accommodated given the recreation facilities after dam breaching. The visitation estimates for general river recreation, presented in Table 3.2-3, reflect the application of these capacity constraints to the demand estimates. In particular, three key capacities were examined: boat ramps, developed campsites, and areas available for primitive camping. Corps recreation planners provided information on the number of boat ramps, developed campsites, and suitable areas for primitive camping. To calculate visitor day capacities, we took the recreation season as April through October. This time coincides with spring break through the steelhead fishing season, as well as summer vacations. This area is attractive in spring and fall, due to the early warm temperatures. While rather hot during the summer, the area receives high use during the vacation months of July and August. Given the average party size of three persons, the maximum number of visitor days that could be accommodated between April and October was calculated with the current number of developed campsites. This figure initially limited the amount of developed camping demand that could be accommodated in all scenarios during the first decade. By the end of the first decade, the river areas would have sufficiently stabilized and the number of developed campsites probably would have more than doubled, fully meeting the demand with the low estimate. More than doubling developed campsites would accommodate about 75 percent of the demand in the middle- and high-use estimates. This would probably coincide with the percentage of developed camping demand met in many popular areas. Primitive camping and primitive camping would be limited during the first few years until the receding beaches became suitable for camping and picnicking. Boat ramp capacity would be sufficient for all use scenarios, although they would be used at close to capacity in the middle-high and high-use estimates. The use estimates presented in Table 3.2-3 reflect the assumption that non-fishing river recreation use would not have to be limited to protect the anadromous fishery.

Table 3.2-3. Number and Distribution of River Trips and Benefits in Year 10

	Percentage	River Recreation Trips	Annual Low NED[1/] ($, Millions)	Annual High NED[1/] ($, Millions)
Low Estimate				
Rural ID,OR,WA	19.50	47,823	3.41	14.20
Rest of Pacific NW	50.10	122,920	8.77	36.51
California	30.40	74,595	5.32	22.15
Total	**100.00**	**245,338**	**17.50**	**72.86**
Middle Estimate				
Rural ID,OR,WA	14.41	66,617	4.75	19.79
Rest of Pacific NW	40.66	188,014	13.42	55.84
California	44.94	207,824	14.83	61.72
Total	**100.00**	**462,456**	**33.00**	**137.35**
Middle-High Estimate				
Rural ID,OR,WA	16.87	128,633	9.18	38.20
Rest of Pacific NW	39.61	295,557	21.09	87.78
California	43.52	331,841	23.68	98.56
Total	**100.00**	**756,031**	**53.95**	**224.54**
High Estimate				
Rural ID,OR,WA	11.45	200,989	14.34	59.69
Rest of Pacific NW	29.51	518,201	36.98	153.91
California	59.04	1,037,003	74.00	307.99
Total	**100.00**	**1,756,193**	**125.32**	**521.59**

1/ The low NED values are consistent with literature for general recreation, while the high NED values are consistent with literature for river angling.

Unlike current conditions, the contingent behavior surveys predict that a large percentage of total river recreation trips would originate in distant areas such as Portland, Seattle, and California with the addition of 140 miles of free-flowing river. Three of the four visitor estimate scenarios indicated that 30 to 45 percent of the total trips would be from California, depending on the sample expansion assumptions. This percentage of trips is not out of line because California represented 60 to 70 percent of the population of the sampling area. Table 3.2-3 illustrates the distribution of trips for each of the three sampling areas with the high and low NED values.

This change in distribution of the origin of visitors with the free-flowing river is consistent with the pattern found in AEI's travel cost analyses of actual visitation. Specifically, the current reservoirs are primarily local-use areas with most of visitors coming from within 100 to 120 miles

(Normandeau et al., 1999; AEI, 1999a). However, in the free-flowing river sections of central Idaho, 21 percent of the river visitors come from 1,000 miles or more away, with 12 percent coming from 1,500 miles or further (AEI, 1999b, 1999c). This pattern is consistent with the lack of availability of substitute rivers of the size and magnitude of the lower Snake River with the dams breached. Thus, people are willing to travel greater distances to visit free-flowing rivers. Besides the limited number of major rivers in the western U.S., many existing rivers such as the Rogue, Salmon, or Colorado have use limits, and permits are rationed by lottery. By contrast, reservoir visitors do not have to travel great distances as there are numerous reservoirs in the local area, including Lake Wallula downstream from Ice Harbor Dam very near the Tri-Cities area, Dworshak Reservoir near Lewiston, Idaho, and three large lakes near Spokane, Washington.

Salmon and Steelhead Fishing

As explained in more detail below, salmon and steelhead fishing demand with dam breaching would be constrained by species availability. The availability of salmon for harvest was estimated by the interagency PATH biologists as extended by the DREW Anadromous Fish Workgroup (1999). The limited availability of salmon for recreational fishing would constrain the angler trips to an annual average of about 500 trips during the first 5 years and an annual average of about 14,000 angler trips over the remaining period of analysis. This would be about 6 percent of the low estimate of salmon angler demand. The same pattern is evident for steelhead, where numbers of fish available for recreational harvest would limit anglers to an annual average of 100,000 days on the mainstem of the lower Snake River over the period of analysis. This represents 50 percent of the lowest estimated demand. As explained in more detail in the next section, a portion of the resident fishing angler demand also would be supplied with Alternative 4, Dam Breaching.

3.2.3 Application of Survey Results to EIS Alternatives

Several different alternatives are evaluated in the EIS. However, from the standpoint of general/non-fishing recreation, these alternatives can be grouped into two main categories: alternatives in which the dams remain (Alternative 1, Existing Conditions, Alternative 2, Maximum Transport of Salmon, and Alternative 3, Major System Improvements) and dam breaching (Alternative 4, Dam Breaching).

3.2.3.1 River Recreation

For Alternative 4, Dam Breaching, the estimated time path of river recovery following dam removal and its influence on recreation suitability and facility availability was estimated by Corps recreation staff. In Table 3.2-2, recreation carrying-capacity estimates by time interval were refined and used to estimate the percentage of the different recreation activities that could be accommodated in each time period. These percentages were applied to the four different estimates of non-angling river recreation demand calculated from the survey. The resulting visitation figures were reduced by the carrying capacity of the developed campgrounds in all but the lowest estimate of river visitor demand. The resulting visitor days were valued using the benefits calculated from the TCM, as described above. In particular, the high NED value scales the TCM demand curve based on the visitor survey responses. The low NED value scales the TCM demand curve based on cost per mile of reservoir visitors as used in the reservoir recreation valuation model of AEI.

3.2.3.2 Recreational Fishing

The estimates of salmon and steelhead that could be recreationally harvested with each alternative were provided by the DREW Anadromous Fish Workgroup. These estimates were based on the preliminary PATH analysis and additional assumptions were made to extend the PATH findings to all Snake River stocks. The workgroup also used information from various international and national fishery treaties to allocate the total stocks to commercial, tribal, and recreational catches. The biological availability of salmon and steelhead for recreational harvest was used to constrain the river angler demand calculated from the household survey data. Specifically, only the proportion of river angler demand compatible with salmon and steelhead available for recreational harvest was counted in any given year. This resulted in only a small fraction of the angler demand indicated in the survey being met.

Details of Resident and Steelhead Fishing Calculation Procedures

Using the Anadromous Fish Workgroup's generalization of PATH estimates of salmon and steelhead with existing reservoirs (Alternative 1, Existing Conditions and Alternative 3, Major System Improvements), the time path of anadromous fishing benefits was calculated for these three alternatives. The changes in salmon and steelhead available for recreational harvest reflected fisheries improvements recently put in place (Alternative 1, Existing Conditions) or proposed improvements with Alternative 2, Maximum Transport of Juvenile Salmon and Alternative 3, Major System Improvements. To estimate the number of angler resident fish trips and steelhead fishing trips, current reservoir fishing trips and fishing trips in the free-flowing stretch above Lewiston were tabulated. These trips were separated into resident fish species and steelhead trips based on information from the Normandeau et al. (1999) analysis. Generally Normandeau and Bennett concluded that there would be minor effects on resident fish for the non-drawdown alternatives (e.g., Alternative 1, Existing Conditions through Alternative 3, Major System Improvements). With Alternative 1, Existing Conditions through Alternative 3, Major System Improvements, resident trips and their value probably would continue into the future. The remaining steelhead trips were related to baseline steelhead harvest figures to calculate trips per steelhead harvested. This factor was applied to future estimates of steelhead harvests provided by DREW Anadromous Fish Workgroup (based on preliminary PATH data) to calculate future steelhead fishing trips. The mainstem resident and steelhead fishing use and benefits are the sum of the resident fishing and the estimated future steelhead fishing.

To estimate the effect of Alternative 4, Dam Breaching, on mainstem resident fish, information on acres of habitat quantity and productivity per hectare (ha) was used (Normandeau and Bennett, 1999). With dam breaching, the surface area of habitat would fall from 13,715.3 to 5,326.7 ha (33,890 to 13,162 acres). However, estimated biomass would increase from 50.9 to 84.7 kg/ha with natural river conditions. If the two effects were combined, there would be a net loss, as the loss in habitat area would be greater than the gained productivity. Based on these two factors, the loss would be about a one-third reduction in resident fish carrying capacity with dam breaching. Thus the estimated resident fishing benefits with Alternative 4, Dam Breaching would be two-thirds of estimated current resident angler trips and benefits.

To estimate the mainstem river steelhead fishing days with Alternative 4, Dam Breaching, two sources of information were used: the hours needed to harvest a steelhead and the conversion of angler hours to angler days. Since this was the same information used in formulating the baseline steelhead catch rate in the contingent behavior survey, the same number was used, 24 hours to harvest one steelhead (Idaho Department of Fish and Game). The average steelhead angler in the free-flowing section of the lower

Snake River fishes 7.2 hours per day (Normandeau et al., 1999). To estimate the benefits of steelhead fishing in the free flowing mainstem of the lower Snake River, the contingent behavior TCM was used (DREW Anadromous Fish Workgroup, 1999). This study yielded a low and high value per day ($39 and $76, respectively) based on whether the demand curve is scaled by the average cost per mile of reservoir anglers McKean used in his work with Normandeau et al. (1999), or whether the survey reported costs of anglers who would use the free-flowing mainstem lower Snake River.

To estimate the number of steelhead fishing days in the tributaries, a process similar to that described above was used, except for some tributary-specific information. The DREW Anadromous Fish Workgroup estimated recreational steelhead harvests in the tributaries for each alternative. Trips per steelhead in year zero were calculated by using current steelhead fishing trips (129,026 trips) in central Idaho tributaries of the Snake River, as estimated by AEI (1999b), divided by the year zero was calculated recreational steelhead harvest. This steelhead-per-trip figure was then applied to the DREW Anadromous Fish Group's estimate of the number of steelhead over the 100-year period of analysis.

Details of Salmon Fishing Calculations

To estimate days of salmon fishing in the mainstem of the Snake River with all alternatives, the estimate used was 35 hours to recreationally harvest one salmon. This information was obtained from the special recreational salmon fishing season on the Hanford reach of the Columbia River. It was used as the low salmon fishing catch rate baseline in the contingent behavior recreation survey. This figure was applied to the DREW Anadromous Fish Workgroup's estimate of recreational harvest allocation for spring/summer and fall chinook salmon with each alternative in each time period to estimate total hours of salmon fishing. As with steelhead, the average length of a fishing day was calculated as 7.2 hours on the mainstem of the lower Snake River. The estimate of salmon fishing benefits came from the contingent behavior survey performed by the DREW Recreation Workgroup (1999), described above. With Alternative 1, Existing Conditions through Alternative 3, Major System Improvements, mainstem lower Snake River salmon fishing would take place in a reservoir setting. Therefore, the salmon fishing value per day applied came from the demand curve scaled by the reservoir anglers' cost per mile obtained from the reservoir fishing analysis. This value was $39 per day for salmon fishing. This was also the low value for the free-flowing river under Alternative 4, Dam Breaching. The high value for Alternative 4, Dam Breaching reflected scaling the demand curve by the reported costs of anglers who said they would come to fish the free-flowing lower Snake River ($76 per day).

To estimate salmon angler days in the tributaries, the same basic approach was used, in particular, the same 35 hours per salmon harvested. The average length of a fishing day was 6.72 hours per the AEI (1999b) survey of central Idaho rivers.

3.2.3.3 Calculation of Present and Annualized Value of Recreation Benefits

Annual values projected over the 100-year study period were used to calculate the present and annualized value of recreation. When using a positive discount rate, the timing of when the different recreation benefits were received would influence the present or annualized value of recreation under each alternative. The time profile of benefits would differ among the alternatives. Alternative 1, Existing Conditions currently provides non-fishing reservoir recreation benefits; these would probably continue each year into the future. However, future fishing benefits would be influenced by recent actions taken to enhance steelhead and salmon populations. The fishery recreation benefits of Alternative 1, Existing Conditions, therefore, would differ slightly from simply extrapolating the current annual benefits. The future recreational fishing benefits for Alternative 1, Existing Conditions were divided by using PATH estimates of steelhead and salmon fishing benefits. Alternatives involving major system improvements or dam breaching would require several years to deliver some of their benefits and several decades for the salmon fishing benefits to be fully realized.

To compare relative worth today, the present worth or present value was calculated using two positive discount rates. These are 4.75 percent (the rate used by BPA) and 6.875 percent, the discount rate used by the Corps for Fiscal Year 1999. This discount rate would weight benefits (and costs) in the near future more heavily than those obtained in the distant future. For purposes of comparison, the tribal discount rate of zero is presented in Table 3.2-4. This would weight all benefits and costs equally over time. The present value of recreation benefits over the 100-year period was converted into average annual equivalent values. The ranking of the proposed alternatives is the same using the average annual or present values.

3.2.4 Summary of Recreation Results

Tables 3.2-4 through 3.2-6 display the average annual equivalent value of the recreation benefits of each of the EIS alternatives at the three different discount rates, respectively. Each table calculates the benefits of Alternative 4, Dam Breaching at a low NED value per day and a high NED value. The low NED value is based on scaling the river recreation and river fishing demand curve using the cost per mile of reservoir visitors. The high NED estimate is based on scaling the demand curve using the costs of visitors to the free-flowing section as reported in the DREW Recreation Workgroup (1999) contingent behavior survey. Overall benefit estimates are presented using the middle-use estimate for river recreation (this uses only those visitors who said they would definitely visit and applies this visitation rate to all households in the region). This middle-use estimate is bracketed by the low-use estimate. This estimate also relies upon the visitation rate of only those individuals stating they would definitely visit, but it conservatively assumes no visitation from households that did not return the survey. Finally, an upper bound is calculated by applying the visitation rate of households that would definitely and would probably visit to all households in the region.

While there has been some debate about the difficulty in predicting anadromous fish populations, as is evident from Tables 3.2-4 to 3.2-7, recreational anadromous fishing is not the majority of the total benefits. In part, this is due to the small allocation of available salmon and steelhead to recreational fishing, as compared to commercial fishing. All four alternatives would have increasing fishing benefits over time, although PATH estimates for Alternative 4, Dam Breaching show the largest salmon and steelhead gains.

Much of the overall gain in recreation benefits of Alternative 4, Dam Breaching over Alternative 1, Existing Conditions through Alternative 3, Major System Improvements would be due to the gain in river recreation days and the value of these days being substantially higher than the loss in recreation activities that could only be undertaken in a reservoir (e.g., waterskiing, etc.). A small part of the gain of the Alternative 4, Dam Breaching high-NED fishing was driven by survey respondents' reported desire to fish for anadromous fish in a free-flowing river environment as compared to a reservoir.

Table 3.2-4. Annualized (AAEV) Value of Recreation Benefits over 100 Years in Millions of 1998 Dollars @ Zero Percent (Tribal Rate)

	1 ($)	2 ($)	3 ($)	4[1/] (Low NED) ($)	4[1/] (High NED) ($)
Reservoir Recreation	31.6	31.6	31.6		
River Recreation					
Low Use Est				44.0	182.6
Middle Use Est				99.4	412.6
High Use Est				441.5	1832.0
Recreational Fishing					
Resident and Steelhead	2.86	2.89	2.88	5.05	8.95
Mainstem Salmon	.55	.73	.68	1.50	2.93
Steelhead-Tributaries	26.35	27.5	27.34	35.42	68.79
Salmon-Tributaries	.27	.33	.31	.81	1.58
Total Middle Use Est	**61.63**	**63.05**	**62.81**	**142.18**	**494.85**
Total Low Use Est				**86.78**	**264.85**
Total High Use Est				**484.28**	**71914.25**

1/ The low NED values are consistent with literature for general recreation, while the high NED values are consistent with literature for river angling.

Table 3.2-5. Annualized (AAEV) Value of Recreation Benefits over 100 Years in Millions of 1998 Dollars @ 6.875 Percent (Corps rate)

	1 ($)	2 ($)	3 ($)	4[1/] (Low NED) ($)	4[1/] (High NED) ($)
Reservoir Recreation	31.6	31.6	31.6		
River Recreation					
Low Use Est				36.18	150.12
Middle Use Est				80.85	335.53
High Use Est				367.18	1523.74
Recreational Fishing					
Resident and Steelhead	2.32	2.35	2.35	3.25	5.44
Mainstem Salmon	.26	.36	.34	.62	1.20
Steelhead Tributaries	19.21	21.07	21.15	24.51	47.61
Salmon Tributaries	.164	.20	.19	.32	.62
Total Middle Use Est	**53.55**	**55.58**	**55.63**	**109.55**	**390.40**
Total Low Use Est				**64.88**	**204.99**
Total High Use Est				**395.88**	**1578.61**

1/ The low NED values are consistent with literature for general recreation, while the high NED values are consistent with literature for river angling.

Table 3.2-6. Annualized (AAEV) Value of Recreation Benefits over 100 Years in Millions of 1998 Dollars @ 4.75 Percent (BPA Rate)

	1 ($)	2 ($)	3 ($)	4[1/] (Low NED) ($)	4[1/] (High NED) ($)
Reservoir Recreation	31.6	31.6	31.6		
River Recreation					
Low Use Est				38.1	158.3
Middle Use Est				85.5	354.9
High Use Est				385.3	1599.1
Recreational Fishing					
Resident & Steelhead	2.43	2.46	2.45	3.64	6.21
Mainstem Salmon	.33	.45	.42	.82	1.60
Steelhead-Tributaries	20.75	22.55	22.58	27.04	52.52
Salmon-Tributaries	19	.23	.22	.42	.81
Total Middle	**55.3**	**57.24**	**57.27**	**117.42**	**416.04**
Total Low				**70.02**	**219.44**
Total High				**417.22**	**1660.24**

1/ The low NED values are consistent with literature for general recreation, while the high NED values are consistent with literature for river angling.

Table 3.2-7. Difference in Annualized AAEV Value of Recreation Benefits from Alternative 1, Existing Conditions Millions of 1998 Dollars @ 6.875 Percent (Corps rate)

	2 ($)	3 ($)	4[1/] (Low NED) ($)	4[1/] (High NED) ($)
Reservoir Recreation	0	0	-31.6	-31.6
River Recreation				
Low Use Est			+36.18	+150.12
Middle Use Est			+80.85	+335.53
High Use Est			+367.18	+1523.74
Recreational Fishing				
Resident and Steelhead	.03	.03	.93	3.12
Mainstem Salmon	.10	.08	.36	.94
Steelhead-Tributaries	1.86	1.94	5.30	28.40
Salmon-Tributaries	.04	.03	.16	.46
Total Middle Use	**2.03**	**2.08**	**56.0**	**336.85**
Total Low Use Est		**11.33**	**151.44**	
Total High Use Est		**342.33**	**1525.06**	

1/ The low NED values are consistent with literature for general recreation, while the high NED values are consistent with literature for river angling.

Table 3.2-7 illustrates the net effect of Alternative 2, Maximum Transport of Salmon, Alternative 3, Major System Improvements, and Alternative 4, Dam Breaching as compared to Alternative 1, Existing Conditions, calculated at the Corps discount rate of 6.875 percent. Specifically, Table 3.2-7 shows the gain or loss in recreation benefits of each alternative compared to the current baseline

(Alternative 1, Existing Conditions), which is used as the future. Based on the PATH fish estimates (as extended from the PATH stocks to all stocks by the DREW Anadromous Fish Workgroup), there would be small gains to salmon and steelhead fishing with Alternative 2, Maximum Transport of Salmon and Alternative 3, Major System Improvements, as compared to Alternative 1, Existing Conditions. The gains in fishing benefits with the Alternative 4, Dam Breaching high-NED value would be significant, amounting to over $30 million, enough to offset the lost reservoir recreation. In addition, there would be large net gains overall due to river recreation with Alternative 4, Dam Breaching, ranging from $11.33 to $1525 million annually, with central estimates between $56 and $342 million annually.

Given that the figures in the low NED column are consistent with literature for general recreation, and that the figures in the high NED column are consistent with literature for river angling, the most likely estimates due to river recreation with Alternative 4, Dam Breaching must be a composite of portions from both the low and the high NED columns presented in Table 3.2-7. This composite would result in the most likely estimate of a benefit of an annual value of $82 million for Alternative 4, Dam Breaching.

3.2.5 Risk and Uncertainty

As in any survey and statistical analysis, there is a degree of uncertainty regarding the exact magnitude of the estimates of visitor use and recreation benefits. This section expands upon the potential range of river-visitor use estimates and provides a range of benefits per trip associated with the various recreation uses.

Reservoir recreation benefits represent three-fourths of the benefits of Alternative 1, Existing Conditions, Alternative 2, Maximum Transport of Salmon, and Alternative 3, Major System Improvements. The reservoir value per trip from AEI (1999a) is $71.31. The 95 percent confidence interval around the mean would be $47 to $148 per trip. Using the 95 percent confidence interval, the annual value of recreation would change from the mean estimate of $31.6 million to a low of $20.8 million to a high of $65.5 million annually.

River recreation benefits also reflect a large portion of the benefits for Alternative 4, Dam Breaching. The mean benefit per trip using the low NED value would be $71.36, with a 95 percent confidence interval of $39 to $446 per trip. Using the visitors’ entire reported trip costs as the price variable in the demand function, river recreation benefits would have a mean value of $297 per trip, with a 95 percent confidence interval of $181 to $831 per trip.

The low and middle estimates in all of the tables in this chapter used just those people indicating that they would definitely visit. Based on the research by Champ et al. (1997), respondents who were sure of their responses had criterion validity with actual cash payments. Since it is likely that at least some of the respondents indicating they would probably visit the lower Snake River if the dams were breached might visit, the low and middle estimates are conservative due to the omission of the “probably visit” respondents. Further, the low estimate reduces the “definitely yes” visitation estimate by the survey non-response rate. That is, the low estimate assumes that none of the non-respondents to the survey would visit the lower Snake River if the dams were breached. Thus, the low estimate is doubly conservative.

3.2.5.1 Avoided Cost Analysis

Breaching the dams in Alternative 4, Dam Breaching would not result in reduction of any significant recreation management costs for the Corps. Most of the Corps recreation maintenance cost is related to the developed campground areas and other developed facilities that would remain under all alternatives. The labor costs associated with rangers would continue as well.

Mitigation

The reservoir recreation effects from breaching the dams in Alternative 4, Dam Breaching would not be directly mitigated. Much of the same water-based recreation probably would continue as today, with the major exception being activities such as waterskiing. The availability of existing nearby reservoirs such as Lake Wallula downstream from Ice Harbor Dam and near Tri-Cities, Dworshak Reservoir near Lewiston, Idaho, and three large lakes near Spokane (Rufus Woods Lake, Coeur d'Alene, and Lake Pend Oreille) would continue to provide opportunities for flat-water recreation.

3.2.6 Conclusion

Table 3.2-7 presents the net changes for each alternative from the base case. Alternative 2, Maximum Transport of Salmon and Alternative 3, Major System Improvements would both provide benefits of approximately $2 million annually.

Table 3.2-7 also presents the net changes for Alternative 4, Dam Breaching. However, these benefits are presented as a range with low and high NED values. The low NED values are consistent with literature for general recreation, while the high NED values are consistent with literature for river angling. Therefore, the Corps believes that the most likely estimate of the net changes for Alternative 4, Dam Breaching, would be a composite of portions from both the low and high NED columns presented in Table 3.2-7. This composite would result in the most likely estimate of a benefit of an annual value of $82 million for Alternative 4, Dam Breaching.

3.2.7 Unresolved Issues

The survey instrument was constructed to determine which types of recreation users would visit the area under a drawdown scenario. The survey further asked the visitors how many times per year they would visit the site. Because responses of less than once per year did not appear to be reasonable, the survey might bias the results and over-estimate usage. Those individuals coming from outside the region might not visit annually. Individuals from outside the region might visit only once every 5 years, once every 10 years, or once in a lifetime. This might result in over-estimating the recreation use by those outside the region. This issue will be further investigated for the final report.

Additionally, a discrepancy was noted during the final stages of this analysis; while the analysis assumed increased benefits from added capacity, the increased costs to create the facilities were not added. This has the effect of understating NED costs and RED short-term benefits (from new construction). RED benefits are addressed in Section 6, Regional Analysis. This issue should be resolved between the draft and final reports.

3.3 Transportation

The four alternatives being evaluated in this Feasibility Study/EIS are Alternative 1, Existing Conditions, Alternative 2, Maximum Transport of Juvenile Salmon, Alternative 3, Major System Improvements, and Alternative 4, Dam Breaching. There would be no change to existing navigation facilities on the lower Snake River under the first three alternatives. Commercial navigation on the lower Snake River would, however, no longer be possible under Alternative 4, Dam Breaching. The following sections present a summary of the effects of dam breaching on the transport of commodities that are now shipped from ports on the lower Snake River. These alternatives are, as a result, represented by the base case in the following discussion.

The following sections address the methodology employed in this analysis, transportation system costs with and without dam breaching, including infrastructure requirements, and uncertainties surrounding the analysis. Details of the analysis are contained in the full-length report developed as part of this feasibility study (DREW Transportation Workgroup, 1999).

3.3.1 Methodology

The methodological approach and analysis of commodity transportation costs is based in part upon analytical techniques that were employed in System Operation Review (SOR) studies performed during 1992-93. The SOR study evaluated a variety of alternative system operating scenarios for the Columbia-Snake River System (CSRS) and quantified the economic effects of each scenario applying national economic development (NED) criteria. This evaluation of breaching the four lower Snake River reservoirs and the resulting economic effects on the existing transportation system uses the same general approach as the SOR and builds upon the methodology and data developed for that study.

The direct economic costs that would result from breaching the four lower Snake River dams are measured and expressed as changes in the NED account. NED costs represent the opportunity costs of resource use, measured from a national rather than a regional perspective. In the case of dam breaching, the change in the cost of transporting products and commodities now shipped from ports on the Snake River is an NED cost, but the loss of revenue and profit by barge companies is not. Only the costs of resources actually used are included in the NED analysis. Although market prices often reflect total opportunity cost of resources, this is not always the case, and surrogate costs must sometimes be used to adjust or replace market prices (or published or contract rates). In this study, for example, it was judged appropriate to use modal costs computed through analysis of the actual fixed and variable costs of each transportation mode—barge, rail, and truck.

The transportation system impacts that would occur under Alternative 4, Dam Breaching, were estimated using a transportation system model that was designed specifically to track and estimate the cost of transporting commodities that now move on the Snake River. Modeling information requirements and assumptions are summarized in the following sections.

3.3.1.1 Modeling Requirements

Measuring the direct economic effects of dam breaching on commercial navigation activity involved evaluating alternative shipping modes and costs, and identifying the most probable combination of storage, handling, and transport modes that would emerge in response to cessation of waterborne transport on the lower Snake River. Specific information required for this analysis included 1) establishment of base and projected future commodity shipments, 2) identification of commodity origins and destinations with and without dam breaching, 3) estimates of modal costs and storage and handling costs at throughput facilities, 4) assessment of regional rail and truck capacity, and 5) assessment of a variety of other elements that characterize the regional transportation system. A brief description of how these data were derived and a description of the procedures and assumptions applied in the evaluation process are presented in the following paragraphs.

Base and Projected Future Commodity Shipments

Projections of future commodity shipments were developed through analysis of waterborne commerce data for the CSRS for the decades of the 1980s and 1990s. The analysis included assessments of exports, the volume of shipments on the Snake River, and the types of commodities shipped. Forecasts of future shipments were developed for each of eight commodity groups and later combined into five groups for the transportation system cost analysis.

Commodity Origins and Destinations

The study area considered in this analysis encompasses grain producing areas as well as origins and destinations for non-grain commodity groups that use the CSRS. Origins of grain transported by barge on the lower Snake River, derived from previous studies conducted in 1992 for the SOR and updated for this study, include areas within northeastern Oregon, eastern Washington, Idaho, Montana, and North Dakota. Origins or destinations for non-grain commodity groups in the lower Snake River region (such as petroleum or fertilizers) also generally fall within this area. The origins of non-grain commodities, which are relatively insignificant in terms of the overall volume of Snake River shipments, were taken directly from data developed for the SOR.

Commodity Growth Forecasts

The basis for commodity growth forecasts is the volume of grain and non-grain shipments that originate from the Snake River above Ice Harbor Dam. These forecasts were based on forecasts originally developed for the Columbia River Channel Deepening Feasibility Study, in conjunction with an analysis of historical data and anticipated trends in the volume of relevant commodities now moving on the lower Snake River. Projections were made at 5-year intervals from 1997 to 2017 for the various commodity groups moving on the lower Snake River segment of the CSRS. Due to the degree of uncertainty inherent in long-range forecasting, projected volumes were assumed to remain level beyond 2017.

Transportation System Cost Estimating Procedures

A Microsoft ACCESS database was developed to estimate transportation-related costs associated with the base condition and the dam-breaching scenario. The database was used to quantify the costs (transportation, storage, and handling) of shipping commodities under existing conditions and in the absence of commercial navigation on the lower Snake River. The results of these two analyses were then compared to determine the effect that river closure would have on transportation system costs. This comparison is simply the difference between transportation costs with dam breaching versus transportation costs without dam breaching.

The model is not an optimization model. It is simply a database of existing and alternative routings of grain and non-grain commodity movements from origins to destinations. Transportation costs under the base case are based on existing routings. Most likely alternative routings are used in the dam breaching case. At least two alternative routings for commodities from each origin are included in the database, and the model is designed to select the lowest-cost routing. Storage and handling costs associated with each alternative routing are added to the transportation cost to determine the total cost associated with each routing. The model accumulates transportation, storage, handling, and total costs for the lowest-cost routings and compiles summary reports on movements and costs by state, county or region, and mode of transportation. In addition, miles (bushel-miles for grain) and ton-miles (for non-grain) are similarly compiled and reported.

Modal Cost Estimating Procedures

Modal costs for barge, rail, and truck were developed using transportation analysis models (TAMs) for each mode. The models used were developed and copyrighted by Reebie Associates, Transportation Management Consultants. The specific models used are briefly described below:

- **Barge Cost Analysis Model (BCAM).** The BCAM is designed to facilitate the analysis of barge-load shipments on the nation's inland waterways. All of the inland waterways on which commercial barge-load shipments are made are built into the model. The model includes data about the river systems, locks and dams, barges, towboats, and commodities. The user operating the model specifies shipment characteristics, cost factors, operating factors, and, routing.

- **Rail Cost Analysis Model (RCAM).** The RCAM is an enhanced personal computer application of the Interstate Commerce Commission's Uniform Rail Costing System (URCS) methodology. The URCS is a complex set of procedures that transforms annually reported railroad expense and activity data into estimates of the costs of providing specific services. It is based an analysis of cause and effect relationships between the production of railroad output ("service units" such as car miles or gross ton miles) and the associated expenses defined by the model's accounting system. These relationships define a series of "unit costs," for example, crew costs per train mile, that are applied to the service units generated by a shipment to produce the estimated cost of providing the service.

- **Truck Cost Analysis Model (TCAM).** The TCAM is used to determine the underlying cost and revenue requirements for truck shipments. The TCAM data input process is divided into three sections: primary shipment specifications (11 variables), driver and utilization factors (10 variables), and detailed costing factors (25 variables). Default values are built into the model for all input variables.

3.3.1.2 Modeling Assumptions

Grain Storage and Handling Costs and Assumptions

Storage costs are a function of two factors, the duration of storage and the monthly cost. The duration of storage is a function of the relationship between harvest and demand. Thus, the duration of storage in the model is the same with and without dam breaching. Differences in costs between the two cases are due to the difference in the cost of storage at the various types of elevators. Elevator storage costs at country and river elevators were reviewed for this study. The review revealed that monthly storage costs at country elevators are about $0.006 per bushel higher than storage costs at river elevators. Thus, the difference in storage cost is due to use of country elevator storage with dam breaching, rather than the cheaper river elevator storage. Storage costs are incurred at all elevator types, with the exception of export terminals. A cost for on-farm storage is not estimated because it would be the same with and without dam breaching.

Handling costs are a function of the number of times grain is required to transfer to a different mode of transportation or to go into or out of storage. The types of movements included in the model are as follows:

Base Case:

- Farm-to-river-to-export terminal
- Farm-to-country elevator-to-river-to-export terminal

Note: The model does not include any farm-to-rail-to-river movements, even though these types of movements have been reported for ports in the Lewiston area and the Port of Wallula.

With Dam Breaching:

- Farm-to-alt river-to-export terminal
- Farm-to-country elevator-to-alt river-to-export terminal
- Farm-to-railhead-to-export terminal
- Farm-to-country elevator-to-railhead-to-export terminal

Storage and handling costs are assumed to be the same for all country elevators, including those with unit-train loading facilties. Handling costs at the export terminals were assumed to be the same for both rail and barge grain deliveries.

Capacity Assumptions

Two general assumptions about capacity are fundamental to the analysis and the construction of the transportation system model. The first assumption is that the current system is in equilibrium in terms of storage, handling, and transport mode capacity. On the basis of this assumption, it was unnecessary to model capacity in the base case. The second assumption is that with dam breaching, modal, handling, and storage capacity can be expanded on a regional basis to meet geographic shifts in demand without significant increases in long-run marginal and average costs. The Economic Procedures and Guidelines the Corps uses to determine project benefits and costs reason that if inland navigation capacity is reduced, competing surface transport modes either possess or would add the capacity necessary to accommodate additional traffic. Similarly, it is assumed that grain elevator throughput capacity could be increased with little impact upon long-run marginal and average costs or unit costs. Therefore, modeling capacity for the dam-breaching scenario was unnecessary for the NED analysis. Specific assessments of capacity infrastructure improvements were, however, made and are discussed in Section 3.3.5. Storage and handling costs for non-grain commodities were assumed to be generally equivalent under either scenario.

Seasonality of Shipments

Shipments of both grain and non-grain commodities experience some month-to-month or season-to-season fluctuations in volume. On a year-to-year basis, many of these fluctuations are due to fluctuations in market conditions rather than the underpinning demand factors. Grain exports from the lower Columbia River may, for example, vary significantly from one month to the next because of market conditions while the demand for grain remains relatively constant. These types of monthly fluctuation are not built into the model used for this analysis. Instead, the model was constructed and operates based on the implicit assumption that volumes of shipments of both grain and non-grain commodities are uniform from month to month.

Alternative Routings

For the base case analysis, the model is designed to replicate a non-optimized base condition based on projected future commodity movements under existing conditions. For the dam-breaching scenario, the model evaluates transportation, storage, and handling costs associated with the shift of projected future volumes of commodities to alternative modes of transportation and routings. The model includes at least two alternative routings for commodities from each origin. In general, alternative routings developed for the SOR were used. These alternative routings were, however, reviewed and updated to take into account changes in unit-train rail loading facilities at country elevators. Alternative rail origins for grain were limited to those having a car-loading capacity of at least 25 cars. This requirement was imposed because for rail transport to be feasible a minimum unit-train loading capability of 25 to 26 cars is needed. This requirement reduced the number of country elevators identified in the base case as having rail access from over 100 to 14. Those facilities that were eliminated are those with a loading capacity of fewer than 25 cars. In addition, facilities within 15 miles of a facility included in the model were excluded on the basis that costs associated with these facilities would be the same as for those already in the model.

Construction of the model further assumes that as grain or other commodity transport is impaired by dam breaching, shipments would be rerouted by motor carriers to river elevators located on the McNary Pool and transshipped by barge, or would be shipped by rail directly to lower Columbia export elevators. The model includes unit costs for transportation, storage, and handling associated with each of the alternative routings for each origin-destination pair affected by waterway closure. Distances between origins and destinations were identified and are included in the model. The overall method employs the assumption that current and projected levels of exports from the region would continue to be maintained.

Adjustment of Model Results

A fundamental assumption made for this analysis is that the existing transportation of grain represents the least-cost condition. Therefore, it was assumed that the cost of all movements of grain with dam breaching should be at least as costly as under the base condition. Actual operation of the model, however, showed that this was not the case. The model results showed that a number of grain movements were found to be less costly with dam breaching than with the existing transportation system. Since this conflicts with the assumption that the existing system is the least-cost system, the model includes a check that identifies whether the cost of a movement is less with dam breaching than under the base condition. If the cost with dam breaching is less, the difference is calculated and added to the transportation costs with dam breaching. The adjustments computed, however, are not tracked in the model by movement, etc., but are simply summed and added to total transportation costs with dam breaching. The use of this type of adjustment is somewhat unconventional, opposed by the IEAB, and is an unresolved issue at this time.

Taxes, Subsidies, and Price Level Changes

The analysis does not take into consideration the effects of taxes or subsidies, which represent transfer payments within the national economy. The effects of potential changes in relative prices are also not considered.

Effects on the Quantity of Land in Grain Production

In the short term, it is possible that some marginal land now used for production of grain could become unprofitable and be taken out of production. The actual impact on individual operators would depend on a number of factors, including the productivity of the land, the fixed cost of land, in the form of capital and interest payments and taxes, and, the actual increase in transportation costs. For most farms, however, the increase in transportation costs would simply mean that the return to fixed capital (such as land) would be reduced. Some land may go out of production in the short term, assuming that grain production is the highest and best use of the land currently used for this purpose. In the long run, however, the reduced economic return to land that would result from higher transportation costs would be reflected in a reduced value of land and the land would continue to be used for grain production. This analysis is, therefore, based on the assumption that implementation of dam breaching would have no effect on the amount land used for grain production. The effects of increased transportation costs on grain producers are discussed in more detail in Section 6 of this appendix.

Period of Analysis, Price Level, and Interest (Discount) Rates

The initial year of dam-breaching implementation is assumed to be 2007, and NED effects are measured over the 100-year period, 2007 to 2106. For purposes of comparison with other fish restoration measures being evaluated in the feasibility study, annual economic costs were adjusted to a base year, 2005.

Uncertainty

A considerable amount of uncertainty exists about modal rate behavior, infrastructure and capacity requirements, the potential for lost grain sales to export markets, and the overall transportation-related financial impacts associated with dam breaching. These issues and the sensitivity of the analysis to alternative assumptions are addressed later in this section.

3.3.2 Navigation Facilities

The Columbia-Snake Inland Waterway is a 465-mile-long water highway formed by the eight mainstem dams and lock facilities on the lower Columbia and Snake rivers. The waterway provides inland waterborne navigation up and down the river from Lewiston, Idaho, to the Pacific Ocean. This system is used for commodity shipments from inland areas of the Northwest and as far to the east as North Dakota. The navigation system consists of two segments: the downstream portion, which provides a deep-draft shipping channel, and the upstream portion, which is a shallow-draft channel with a series of navigation locks.

The deep-draft portion of the navigation system consists of a 40-foot-deep by 600-foot-wide channel that extends up the Columbia River from the Columbia Bar (River Mile [RM] 3.0) to Vancouver, Washington (RM 105.6). Major import-export terminals are located adjacent to the channel at the Columbia River ports of Vancouver, Longview, and Kalama in Washington, and Portland and Astoria in Oregon.

The shallow draft portion of the waterway is a Federally maintained channel and system of locks that extends from Vancouver, Washington, to Lewiston, Idaho. The channel extends up the Columbia River from Vancouver, Washington (RM 106), to Richland, Washington (RM 345), and from the mouth of the Snake River (Columbia River RM 325) to Lewiston, Idaho (Snake River RM 141). This channel has a minimum authorized depth of 14 feet at the minimum operating pool (MOP) elevations of each of the upstream dams.

The presence of the Columbia-Snake River Inland Waterway has led to the development of a sizable river-based transportation industry in the region. Riverside facilities managed by port districts and various other public and private entities are located on the pools created by the system of dams and locks. Fifty-four port and other shipping operations provide transportation facilities for agricultural, timber, and other products. There are 22 port facilities located along the shallow draft portion of the waterway, including nine on the lower Snake River. All of the ports on the lower Snake River have grain-handling capability.

3.3.3 Waterborne Commerce

3.3.3.1 Columbia River Deep-Draft Channel

The Columbia River serves an extensive region that covers much of the western United States. Within the region, a variety of commodities, foodstuffs, and other products are produced. Of those industries within the region that generate waterborne commerce, agriculture predominates, particularly with respect to the production of grains such as wheat and barley. In addition, corn, which is produced outside of the region, represents a significant volume of shipments from export terminals on the lower Columbia River. Other regional industries that use water to transport products include aluminum, pulp and paper, petroleum products, and logs and wood products. In terms of volume, wheat and corn represent the major share of total commodities shipped on the deep draft segment of the Columbia River channel. Other products include autos, containerized products, logs, petroleum, chemicals, and other miscellaneous products. Countries involved in the region's export trade are Japan, Korea, and Taiwan, as well as other Pacific Rim countries.

3.3.3.2 Columbia-Snake Inland Waterway

Products shipped on the shallow draft segment of the river system consist principally of grain, wood products, logs, petroleum, chemicals, and other agricultural products. Bulk shipments make up much of the waterborne traffic on the upstream channel. A number of commodities, principally non-grain agricultural and food products and paper products, are shipped via container. Approximately 97 percent of downriver-bound container shipments are destined for Portland, Oregon, with the remainder going to Vancouver, Washington. Historically, the bulk of upriver barge shipments have been made up of petroleum products.

Analysis of data from the Waterborne Commerce Statistics Center (WCSC) and the Corps' Lock Performance Monitoring System (LPMS) showed that commodities from 37 commodity groups were shipped on the waterway in both 1996 and 1997. These commodity groups were aggregated into five groups for the purposes of this analysis—grain, petroleum products, wood chips and logs, wood products and other. Shipments from 1992 to 1996 are shown in Table 3.3-1.

Table 3.3-1. Tonnage of Shipments by Commodity Group on the Shallow Draft Portion of the Columbia-Snake Inland Waterway from 1992 to 1996

Commodity Group	**Thousand Tons**				
	1992	**1993**	**1994**	**1995**	**1996**
Grain	4,612.9	4,902.3	5,671.4	5,883.3	5,710.4
Petroleum Products	1,567.1	1,746.1	1,693.1	2,164.6	2,023.2
Wood Chips and Logs	1,837.3	2,130.8	2,056.4	1,779.2	1,281.9
Wood Products	61.3	44.7	63.1	73.4	28.1
Other	1,224.7	761.9	615.3	626.9	629.6
Total	**9,303.3**	**9,585.8**	**10,099.3**	**10,527.4**	**9,673.2**

Source: Waterborne Commerce Statistics Center (WCSC), New Orleans, LA, and Corps' Lock Performance Monitoring System (LPMS)

3.3.3.3 Lower Snake River

Commodity movement on the lower Snake River is dominated by grain (primarily wheat and barley), which made up 75.8 percent of the tonnage passing through Ice Harbor lock from 1992 to 1997. During the same period, wood products, including wood chips and logs, accounted for 15.8 percent, petroleum products accounted for another 3.0 percent, paper and pulp accounted for 2.3 percent, and all other commodities accounted for the remaining 3.0 percent. Table 3.3-2 provides a summary of the annual tonnage by commodity group passing through Ice Harbor lock from 1992 through 1997.

The Columbia-Snake Inland Waterway from Lower Granite pool through McNary Dam handled cumulative totals of approximately 6.7 million tons in 1990, 7 million tons in 1991, and 6.7 million tons in 1992. This included upbound and downbound cargo originating at Lower Granite, Little Goose, Lower Monumental, Ice Harbor, and McNary reservoirs (Corps and NMFS, 1994). Since 1980, cumulative cargo volumes have ranged from approximately 5 million to 8 million tons per year. Tonnage using at least a portion of the Snake River segment, as measured by data for Ice Harbor, averaged about 3.8 million tons per year from 1980 through 1990. This average increased slightly to about 4 million tons per year from 1992 through 1997 (Table 3.3-2).

Table 3.3-2. Tonnage by Commodity Group Passing through Ice Harbor Lock 1987-1996 (thousand tons)

Commodity Group[1/]	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**Average**
Grain	2,906	3,981	2,532	3,109	3,241	2,612	2,706	3,135	3,471	2,821	3051.4
Wood Chips and Logs	461	394	320	304	375	500	854	910	857	530	550.5
Petroleum	117	105	115	108	106	108	129	137	144	95	116.4
Wood Products	46	52	45	42	74	61	45	58	68	28	51.9
Other	96	127	203	166	159	80	57	74	82	85	112.9
Total	**3,626**	**4,659**	**3,215**	**3,729**	**3,955**	**3,361**	**3,791**	**4,314**	**4,622**	**3,559**	**3,883**

1/ All figures are rounded to the nearest 1,000

Notes: Large movements of 1.2 million tons in 1988 and 1.4 million tons in 1989 have been omitted because they appear to have been one-time movements and would significantly skew the "All Other" category in which they were classified (see DREW Transportation Group).

Ice Harbor lock was out-of-service from January 1 through March 9, 1996, while the downstream lift gate was being replaced.

Source: Waterborne Commerce Statistics Center (WCSC), New Orleans, LA, and Corps' Lock Performance Monitoring System (LPMS)

3.3.3.4 Projected Growth in Commodity Shipments

The U.S. Army Corps of Engineers, Institute for Water Resources (IWR) developed a forecast of future commodity growth for the major commodity groups that are presently shipped on the lower Snake River. The basis for the forecast was the commodity forecast developed for the Corps' Columbia River Channel Deepening Feasibility Study. Historical data for Snake River shipments were compiled for aggregated commodity groupings for the 10-year period from 1987 through 1996. This data set was used as the basis for projecting future growth as a share of forecast growth for the Columbia River. Projections were initially established at 5-year increments to encompass a 20-year period, 2002 through 2022. As stated earlier, for the dam, breaching option, the implementation date is assumed to be 2007; therefore, the evaluation used projections for the period from 1997 to 2017, with growth held constant thereafter. The rationale and basis for estimating future growth in volume for the respective commodity groups are described below.

Grain

Historic wheat and barley exports from the Lower Columbia are compared with shallow draft wheat and barley shipments from the lower Snake River above Ice Harbor in Table 3.3-3. From 1987 to 1996, shipments on the lower Snake River averaged about 23.4 percent of wheat and barley exports from the lower Columbia River and ranged from a high of 26.5 percent share in 1991 to a low of a 20.2 percent share in 1992. This is a relatively low range, with fluctuations from year to year probably being driven by variations in grain production among the regions. Also shown in the table is the year-to-year change in percent share for the Snake River.

Table 3.3-3. Wheat and Barley Exports From the Lower Columbia Compared With Shipments from the Lower Snake River above Ice Harbor, 1987-1996 (in thousand tons)

Wheat & Barley	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	Avg.
Lower Columbia Exports	12,085	14,945	10,458	11,778	12,233	12,762	13,428	14,908	14,603	13,691	13,089
Snake River Shipments	2906	3981	2532	3109	3241	2612	2706	3135	3471	2821	3,051
Snake River %	24.0	26.6	24.2	26.4	26.5	20.5	20.2	21.0	23.8	20.6	23.38
Change in %	--	2.6	-2.4	2.2	0.1	-6.0	-0.3	0.9	2.7	-3.2	

Source: Waterborne Commerce Statistics Center (WCSC), New Orleans, LA, and Corps' Lock Performance Monitoring System (LPMS)

The average Snake River share of 23.4 percent of exports of wheat and barley from the lower Columbia River is used as the basis for forecasting future wheat and barley movements on the Snake River above Ice Harbor. The forecast was made by applying this percentage to projected exports for wheat and barley developed for the Columbia River channel deepening study. The resulting forecast is summarized in Table 3.3-4.

Table 3.3-4. Waterborne Traffic Projections above Ice Harbor Lock 2002-2022 (in thousand tons)1/

Commodity Group	Average	2002	2007	2012	2017	2022
Grain	3,019	3,647	3,799	3,798	3,892	4,052
Wood Chips and Logs	716	694	694	694	694	694
Petroleum Products	118	127	136	145	156	167
Wood Products	52	66	79	101	128	148
Other	81	97	110	128	148	167
Total	**3,986**	**4,631**	**4,818**	**4,866**	**5,018**	**5,228**

1/ These projections are the medium or "most likely" values projected in the navigation analysis. The Portland District's analysis also provided low ("likely minimum") and high ("likely maximum") values for each year. The averages are computed across all three values for each year.

Source: Snake River Commodity Projections, IWR Navigation Data Center, Ft. Belvoir, VA.

Wood Chips and Logs

In terms of tons, the next largest commodity group using the Snake River above Ice Harbor, after wheat and barley, is wood chips and logs. Between 1987 and 1996, shipments of wood chips and logs varied from a low of 303,800 tons (1990) to a high of 909,600 tons (1994), with an average of 716,100 tons from 1991 to 1996. Although 1997 data were not available as this report was being compiled, data from the LPMS suggest 1997 wood chips and logs traffic was about 594,000 tons at Lower Granite Dam. Using this information as a proxy for 1997 movements on the Snake River above Ice Harbor, it appears this commodity group recovered some of the traffic lost in 1996, but did not attain the robust traffic levels experienced from 1993 to1995. Adding in the 1997 estimate to the average base traffic calculation reduces this value to 694,200 tons. This is the amount carried forward into the forecast analysis.

With an R-squared of .37, the historic data for 1987 to 1997 do not indicate a clear linear trend that could be used for credible forecasting. The traffic in wood chips and logs appears to vary around an average level, increasing or decreasing with market conditions, but without the prospect of sustained long-term positive growth. This assessment has generally been confirmed in conversations between Portland District and commercial shippers who have reported future traffic expectations as "flat" or stable. For this reason, the forecast for wood chips and logs has been held steady at the adjusted (to include the 1997 estimate) average of 694,200 tons. Since no growth is being forecast for the base traffic, these figures are the same in each forecast year. The forecast is shown in Table 3.3-4.

Petroleum Products

Petroleum products, the third largest commodity group transported on the lower Snake River, generally account for approximately 80 percent of all upriver commodity movements above Ice Harbor lock (Corps and NMFS, 1994). Annual petroleum product shipments ranged from 95,000 tons in 1996 to 144,000 tons in 1995, with an average of 116,000 tons from 1987 through 1996. Conversations with terminal managers indicated that shipments of petroleum by barge tend to decline when excess refinery production in the Great Plains and Rocky Mountain regions further east becomes available by pipeline in the Spokane area. From there, petroleum products can be trucked in competitively. When those supply routes tighten and prices increase, barged petroleum from the Portland area becomes more competitive.

The forecast assumes these competitive supply dynamics will continue in the future, but with a generally upward trend in barge traffic as the demand for petroleum products in the Snake River hinterland increases with general population and economic growth. Historic population data for the Snake River hinterland counties indicates an average annual increase of 1.4 percent since 1980 and 1.7 percent since 1990. Forecast growth is based on the longer-term population growth rate of 1.4 percent. The resulting forecast is shown in Table 3.3-4.

Wood Products and Other

Of the commodity categories being assessed in the present analysis, it was observed that "other farm products" (that is, all farm products other than wheat and barley) and "wood products" (including pulp and waste paper, paper products, and primary wood products) were most likely to be containerized. The forecast referenced above was adapted to the lower Snake River through an analysis of container movements on the Columbia and Snake rivers, with the assumption that the Snake River's share of the total would remain unchanged over the forecast period. The forecast for chemicals, which primarily consist of fertilizer and ammonia, was based on the forecast for grain with the assumption that the ratio of the grain to chemicals ratio would remain constant over time. The resulting forecasts are shown in Table 3.3-4.

Summary

In all, projections were made for eight commodity groups. These groups were then combined into the five groups and were included in the transportation model. The "other" commodity group includes other farm products, chemicals, containers, and all other. The medium or base forecast for each commodity group is shown in Table 3.3-4.

3.3.4 Base Condition Transportation Costs

3.3.4.1 Modeling Considerations

One of the key elements in determining commodity transport costs is identifying origins and destinations of product movements. Within the Columbia River Basin, country elevators located in one county may collect and store grain from sources in several adjacent counties. This means that grain may ultimately be transshipped to river elevators located in other counties. These movements, as such, tend to have a three-dimensional aspect in terms of origins and interim destinations. In order to reduce the complexity of data management, country elevators were considered to be the starting point for the movement of grain down-river, with the exception of those grain shipments made directly from farm to river elevators. This eliminated the need for a three-dimensional approach that would vastly enlarge the magnitude and complexity of the commodity flow data. The effect of this modeling convention on estimated costs is to understate costs by the amount of the cost to move grain from farms to country elevators, however, the overall costs of moving grain from farms to country elevators or other interim holding facilities are unlikely to differ significantly between base and dam breaching conditions. For modeling purposes, therefore, this simplifying assumption was applied except in those cases where grain is transported directly from farm to river elevators, without dam breaching. With dam breaching, modeling was based on the assumption that farm-to-river elevator shipments would now move directly from farms to country elevators with unit train loading capacity. This may not be the case for specific farms because some farm-to-river movements of grain may be determined by the relative location of farms to the river elevators. The assumption is, however, considered to be valid in general because with dam breaching other farms would be expected to be located near elevators with rail loading capacity.

Modal and Other Costs

The next step in computing transportation costs was to input modal costs for each origin/destination pair. As explained previously, modal costs were developed for the study using models developed and maintained by Reebie Associates. Costs assigned for the base condition, for example, included the cost of the grain movements by truck from country elevators to river elevators within the dam breaching reach, and then the cost to move the grain by barge to export terminals. Storage and handling costs are also included. These latter costs are based on rates charged for these services, rather than on NED-based costs, as is the case with modal costs.

Other Considerations

In the process of evaluating data obtained and applied in this analysis, it was determined that grain from Montana and North Dakota is normally shipped to the CSRS as a backhaul for building materials that are transported to these states and eastward as far as Chicago. Since backhaul shipments are required to only generate sufficient revenue to pay the incremental costs of the shipment, this significantly reduces costs. For this evaluation, it was judged that backhaul shipments of grain by truck from Montana and North Dakota origins to Lewiston would continue in the future. With dam breaching, however, the river destination would shift from Lewiston to the Tri-Cities area. It was further assumed that all long-distance grain movements (in excess of 150 miles) include backhauls. Accordingly, truck movements of grain of 150 miles or more were given a backhaul-based cost.

Storage and handling rates were obtained for each elevator type—country and river. In compiling these data, it was noted that there is a significant variation in rates that are charged. Further analysis indicated that the variation is due largely to market strategies of owners of multiple facilities. It was necessary to make adjustments to some of the raw data to derive the average rates that were used in the model.

3.3.4.2 Transportation Costs — Base Condition

For the base condition, grain transportation, storage, and handling costs were based upon current and projected levels of commodity flows (see Section 3.3.1). Model estimates of the costs displayed in Table 3.3-5 below are for projected grain movements for 2007. Costs are not shown for any of the other years included in the forecast because projected growth in the volume of grain does not have a significant effect on costs at the per bushel or even per ton levels. Total cost (in dollars), cost per bushel (in cents), and cost per ton (in dollars) are shown for each state. Estimates of total costs per bushel range from a high of about $7.10 for Montana to a low of $0.34 for Oregon. These costs are, however, simply estimates as the estimate for Montana clearly suggests. These costs, especially for storage and handling, at nearly $6.50 per bushel, are much higher than actual costs. The DREW Transportation Study Team is aware of this problem, and corrections have been made to the model. These corrections were not made in time to be included in this document, but will be included in the next version. This does not, however, affect the primary objective of the analysis — to estimate the change in costs if dam breaching were to occur — because these costs are the same with and without dam breaching.

Table 3.3-5. Base Condition Grain Shipments and Transportation, Storage, and Handling Costs for 2007 Projected Volume, by State

State	Grain Quantity	Transportation Cost ($)	Storage Cost ($)	Handling Cost ($)	Total Cost ($)
Idaho					
Cost Per Bushel	32,289,941	.347	.147	.215	.709
Cost Per Ton	968,795	11.55	4.91	7.16	23.62
Total Cost		11,193,026	4,758,470	6,932,211	22,883,707
Montana					
Cost Per Bushel	6,537,310	.717	3.065	3.313	7.095
Cost Per Ton	196,139	23.90	102.16	110.41	236.47
Total Cost		4,687,358	20,038,366	21,655,789	46,381,513
North Dakota					
Cost Per Bushel	2,458,172	1.327	0.0	0.0	1.327
Cost Per Ton	73,753	44.23	0.0	0.0	44.23
Total Cost		3,262,017	0	0	3,262,017
Oregon					
Cost Per Bushel	980,218	.339	0.0	0.0	.339
Cost Per Ton	29,409	11.28	0.0	0.0	11.28
Total Cost		331,837	0	0	331,837
Washington					
Cost Per Bushel	84,355,029	.203	.157	.224	.584
Cost Per Ton	2,530,904	6.77	5.24	7.46	19.46
Total Cost		17,127,974	13,258,963	18,868,710	49,255,647
Totals					
Cost Per Bushel	126,620,670	.289	.301	.375	.964
Cost Per Ton	3,799,000	9.63	10.02	12.49	32.14
Total Cost		**36,602,212**	**38,055,799**	**47,456,710**	**122,114,721**

Costs associated with grain transport under the base condition were converted to average annual amounts over the period of analysis from 2007 to 2106. These average annual amounts, that reflect zero, 4.75, and 6.875 percent rates of interest, are presented in 1998 dollars in Table 3.3-6.

Table 3.3-6. Base Condition – Grain, Average Annual Costs, 2007 – 2106 (1998 dollars)

Interest Rate (%)	Average Annual Costs ($)
6.875	126,042,205
4.75	126,963,320
0.00	129,337,780

Non-Grain Commodities

For purposes of analysis, non-grain commodities were combined into four groups: petroleum, logs and woodchips, wood products, and other. The other group is comprised of other farm products, containerized products, and chemicals. For the base condition, transportation costs reflect current and projected volume. Transportation costs associated with non-grain commodities for selected years under the base condition are presented in Table 3.3-7.

Table 3.3-7. Base Condition Total Annual Transportation Costs for Non-grain Commodities for 2002, 2007, 2012, and 2017 (1998 dollars)

Year/Commodity Group	Base Case ($)
2002	
Petroleum	14,838,745
Logs and Wood Chips	47,879,179
Wood Products	4,380,282
Other	6,125,027
Total	73,223,233
2007	
Petroleum	15,893,106
Logs and Wood Chips	47,879,179
Wood Products	5,242,586
Other	6,946,350
Total	75,961,221
2012	
Petroleum	16,936,369
Logs and Wood Chips	47,879,179
Wood Products	6,703,299
Other	8,084,392
Total	79,603,239
2017	
Petroleum	19,511,230
Logs and Wood Chips	47,879,179
Wood Products	8,494,810
Other	9,345,900
Total	85,231,119

Costs associated with non-grain commodities were converted to average annual amounts over the period of analysis from 2007 to 2106 and are displayed below in Table 3.3-8. These average annual amounts, computed at zero, 4.75, and 6.875 percent rates of interest, are expressed in 1998 dollars.

Table 3.3-8. Base Condition Average Annual Costs for Non-Grain Commodities, 2007-2106 (1998 dollars)

Discount Rate (%)	Average Annual Costs ($)
6.875	82,274,899
4.750	83,006,143
0.000	84,671,628

Base Condition Summary

Transportation costs associated with all commodities under the base condition are presented in Table 3.3-9. They were computed at zero, 4.75, and 6.875 percent rates of interest, expressed in 1998 dollars, and converted to average annual amounts for the period of analysis from 2007 to 2106.

Table 3.3-9. Summary of Base Condition Total Average Annual Costs—All Commodities, 2007-2106 (1998 dollars)

Discount Rate (%)	Average Annual Costs ($)
6.875	208,317,104
4.750	209,969,463
0.000	214,009,408

Adjustment of Annual Costs to the Base Year

Average annual costs in Table 3.3-10 were adjusted to the base year of 2005 to be consistent with analyses of other fish restoration alternatives. This was done by discounting the values from 2007 to 2106 (Table 3.3-9) by 2 years at the appropriate discount rate. The adjusted annual costs are shown in Table 3.3-10.

Table 3.3-10. Annual Costs Adjusted to the Base Year of 2005—All Commodities (1998 dollars)

Discount Rate (%)	Average Annual Costs ($)
6.875	182,377,458
4.750	191,358,639
0.00	214,009,408

3.3.5 Dam Breaching Condition

3.3.5.1 Geographic Scope of Impacts

The geographic scope of this analysis includes all communities, port facilities and terminals that are located adjacent to the lower Snake River and have direct access to the navigation channel. This scope also includes inland areas geographically distant from the CSRS that make significant use of the navigation system. Grain export-elevators on the lower Columbia River are part of the study area but export destinations, such as Pacific Rim nations in Asia as a practical matter, are not. A fundamental premise of the analysis is that with dam breaching, export markets will continue to be supplied with the same reliability as the existing system provides.

The analysis of the economic effects of dam breaching on grain producers is limited to the potential changes in how grain is shipped to export terminals in the Portland area and the associated changes in costs. The analysis and results are general in nature and do not apply directly to specific grain producers.

3.3.5.2 Alternative Transportation Modes And Costs

With loss of access to the Snake River portion of the CSRS, commodities would move by the next least costly available mode, such as rail direct to export elevators on the lower Columbia or by truck to river elevators located on the McNary pool. For the dam-breaching scenario, the evaluation process in most cases considers the following two alternatives: the use of truck-barge combination to the closest river terminal unimpaired by dam breaching, or truck transport to the closest rail loading facility with multi-car loading facilities. Where rail access is presently available at country elevators, grain would either shift to rail direct from those locations, or be moved by truck to a rail distribution point where unit trains could be assembled. At country elevators where rail is presently the primary means of transport, this would remain the case with dam breaching. As with the base condition, modal costs were prepared for rail, barge, and truck movements using the Reebie models.

3.3.5.3 Alternative Origins

If dam breaching were to occur, grain now shipped via the lower Snake River would shift to alternative modes of transportation. Commodities would either be rerouted via truck to river elevators located on McNary pool or shipped by rail directly to export elevators on the lower Columbia River. To evaluate the transportation, storage, and handling costs associated with this shift, it was necessary to identify alternative origins and intermediate destinations. Alternative destinations were identified through review and revision of the alternative destinations identified in SOR (Corps, 1995). The alternative rail origins (intermediate destinations) of grain shifted from the lower Snake River to rail are shown in Table 3.3-11. Each of these facilities currently has the capability of loading unit trains of 26 or more railcars. The actual number of elevator facilities with unit-train loading capability is significantly greater than the number of facilities included in the model. On the Burlington Northern Santa Fe (BNSF) system, there are actually 39 facilities in eastern Washington and 4 in northern Idaho. These facilities have a combined storage capacity of just slightly less than 53.6 million bushels (bu). For grain now shipped through lower Snake River ports that would continue to be shipped by barge, the alternative barge origin (intermediate destination) is the area close to the confluence of the Snake and Columbia rivers, including the Tri Cities.

Table 3.3-11. Alternative Rail Origins of Grain With Dam Breaching

Origin	County	Capacity (bu)	Railroad
Washington			
Coulee City	Grant	2,038,000	Palouse R. and Coulee City (PCC)
Plymouth	Benton	4,129,000	BNSF
Harrington (2)	Lincoln	2,579,000	BNSF
Odessa (Lamona)	Lincoln	638,000	BNSF
Spangle (3)	Spokane	1,235,000	PCC & BNSF
Spangle	Whitman	3,440,000	PCC & BNSF
Idaho			
Craigmont	Lewis	1,744,000	Camas Prairie RailNet
Grangeville	Idaho	1,552,000	Camas Prairie RailNet
Idaho Falls	Bonneville	Na	Union Pacific
Pocatello	Bannock	Na	Union Pacific
Nampa	Canyon	Na	Union Pacific
Mountain Home	Elmore	Na	Union Pacific
Bliss	Gooding	Na	Union Pacific
Burley	Cassia	Na	Union Pacific
American Falls	Power	Na	Union Pacific
Blackfoot	Bingham	Na	Union Pacific
Oregon			
Pendleton	Umatilla	Na	Union Pacific

Notes: There are multiple facilities at some locations, as indicated by the number in parentheses following the city name.
na = not available.

3.3.5.4 Transportation Costs with Dam Breaching

Grain transportation costs under the dam-breaching option were developed based upon the projected commodity flows that would be diverted to alternative modes and alternate intermediate destinations. Estimates of the costs associated with projected grain movements in 2007 are presented in Table 3.3-12. Storage and handling costs of grain movements are also shown. Total cost (in dollars), cost per bushel in cents (cts), and cost per ton (in dollars) are shown for each state. Data are presented for 2007 because this is the year that actual dam breaching would begin, and commodity shipments would be diverted away from the lower Snake River. If dam breaching were to occur, estimated grain transportation costs would range from 40.1 cents per bushel in Oregon to $7.30 per bushel in Montana. Most of the cost for Montana is due to storage and handling costs. While these charges are unrealistic, they were handled the same way in the model with and without dam breaching. As a result, the difference between the two cases is likely to be more realistic than the estimates for each case.

Table 3.3-12. Dam-breaching Grain Shipments and Transportation, Storage, and Handling Costs for 2007 Projected Volume, by State[1/] (1998 dollars)

State	Grain Quantity	Transportation Cost ($)	Storage Cost ($)	Handling Cost ($)	Total Cost ($)
Idaho					
Cost per Bushel	32,289,941	.500	.175	.227	.903
Cost per Ton	968,795	16.67	5.83	7.58	30.08
Total Cost		16,148,010	5,652,855	7,342,505	29,143,370
Montana					
Cost per Bushel	6,537,310	.928	3.065	3.313	7.305
Cost per Ton	196,139	30.91	102.16	110.41	243.49
Total Cost		6,063,389	20,038,366	21,655,789	47,757,544
N. Dakota					
Cost per Bushel	2,458,172	1.433	0.0	0.0	1.433
Cost per Ton	73,753	47.78	0.00	0.00	47.78
Total Cost		3,523,573	0	0	3,523,573
Oregon					
Cost per Bushel	980,218	.401	0.0	0.0	.401
Cost per Ton	29,409	13.37	0.00	0.00	13.37
Total Cost		393,165	0	0	393,165
Washington					
Cost per Bushel	84,355,029	.340	.176	.232	.749
Cost per Ton	2,530,904	11.35	.586	7.75	24.96
Total Cost		28,714,849	14,838,964	19,605,738	63,159,551
Totals					
Cost per Bushel	126,620,670	.433	.230	.384	1.137
Cost per Ton	3,799,000	14.44	10.67	12.79	37.90
Total Cost		**54,842,986**	**40,530,185**	**48,604,032**	**143,977,203**

1/ Totals exclude an adjustment of $794,781 calculated by the model and added to the regional total to prevent costs for any movement with dam breaching from being lower than without dam breaching.

Costs associated with grain transport under the dam-breaching condition were converted to average annual amounts for the period of analysis 2007 to 2016. These average annual amounts, computed at zero, 4.75, and 6.875 percent rates of interest, in 1998 dollars, are shown below in Table 3.3-13.

Table 3.3-13. Dam Breaching Condition – Grain, Average Annual Costs, 2007–2106 (1998 dollars)

Discount Rate (%)	Average Annual Cost ($)
6.875	148,870,766
4.750	149,958,712
0.000	152,763,231

3.3.5.5 Non-grain Commodities

For purposes of analysis, non-grain commodities were combined into the same groupings used for the base condition analysis. Estimated transportation costs reflect projected commodity volumes. Transportation costs associated with non-grain commodities for selected years under dam-breaching conditions are presented in Table 3.3-14.

Table 3.3-14. Dam-breaching Condition Total Annual Transportation Costs for Non-grain Commodities for 2002, 2007, 2012, and 2017 (1998 dollars)

Year/Commodity Group	Dam Breaching Case ($ 1998)
2002	
Petroleum	15,350,816
Logs and Wood Chips	49,320,040
Wood Products	5,444,873
Other	6,643,160
Total	76,758,889
2007	
Petroleum	16,441,562
Logs and Wood Chips	49,320,040
Wood Products	6,516,753
Other	7,533,960
Total	79,812,315
2012	
Petroleum	17,520,827
Logs and Wood Chips	49,320,040
Wood Products	8,332,480
Other	8,768,272
Total	83,941,619
2017	
Petroleum	20,184,544
Logs and Wood Chips	49,320,040
Wood Products	10,559,403
Other	10,136,495
Total	90,200,482

Costs associated with non-grain commodities under dam breaching conditions are displayed in Table 3.3-15 as average annual amounts for the period of analysis from 2007 to 2106. These average annual amounts, computed at zero, 4.75, and 6.875 percent rates of interest, are expressed in 1998 dollars.

Table 3.3-15. Dam-breaching Condition Average Annual Costs for Non-grain Commodities, 2007 – 2106 (1998 dollars)

Interest Rate (%)	Average Annual Costs ($ 1998)
6.875	86,898,809
4.750	87,715,836
0.000	89,575,894

3.3.5.6 Infrastructure Requirements and Costs

With dam breaching and a shift of commodities from shipment on the lower Snake River to shipment by rail, there would a significant increase in demand on the region's land-based transportation and grain handling infrastructure. This section addresses rail system requirements, rail car capacity, highway system requirements, and elevator capacity requirements. In all cases, a range of costs (low and high) was estimated due to uncertainties about actual needs and costs. The following sections briefly describe infrastructure needs and present a summary of the associated costs. The methodology employed to identify these costs is discussed in the DREW Transportation Report (DREW Transportation Study Team, 1999).

Rail System Requirements

If dam breaching were to occur, rail system requirements would include improvements to existing rail lines in terms of interchanges between short-line and mainline carriers, track upgrades, and bridge upgrades. In addition, the stock of grain cars would have to be expanded.

Mainline (Class 1) Railroads

Both mainline railroads, BNSF and Union Pacific, would be impacted by dam breaching through the shift of grain and other commodities from the Snake River to rail. In this analysis, it is assumed that all commodities shifted to rail would eventually require the services of these mainline carriers to reach their final destinations at ports on the lower Columbia River. The increase in grain shipments alone would increase traffic on the mainline routes by from about 840 to about 940 railcar-trips per month. Assuming a train size of 108 cars, this represents an increase of from about eight to nine additional trains per month destined to ports on the lower Columbia River. This would be a significant increase in rail traffic, and improvements to the existing mainline system may be needed.

In making the assessment of mainline railroad infrastructure needs and costs, estimates of diverted traffic and generic or "rule of thumb" measures were used. Generic measures for costing the construction or modification of line capacity were developed for this purpose by civil engineers at the University of Tennessee's Transportation Center. Preliminary estimates were discussed with engineering professionals from a number of Class 1 railroads and with experts from private construction firms that are routinely engaged in rail project construction. Officials of BNSF, Union Pacific, and others reviewed these estimates as they apply to the Pacific Northwest rail system. Estimated costs ranged from $14 million to $24 million.

The impact of the need to make infrastructure improvements to mainline railroads on long-run marginal costs of the railroads was evaluated in a study conducted for the Corps by the Tennessee Valley Authority

(TVA) and Marshall University (TVA and Marshall University, 1998). This study examined the estimated increase in volume, assuming that all commodities now moving on the Snake River would be diverted to rail (a worst-case scenario), and a number of strategies for increasing line-haul capacity. The study concluded that the necessary infrastructure improvements could be made without putting any upward pressure on long-run marginal costs or rates.

Short-Line (Class 2) Railroads

If dam breaching were to occur, short-line railroads in Idaho and Washington would likely experience increased shipments of grain. The magnitude of this increase was not projected for individual railroads or even to the short-line railroads as a group as part of this study. As a result, the assessment of impacts on these carriers and the estimates of costs of improvements are general in nature. Cost estimates were not specifically developed for this study. In the case of Washington railroads, costs were taken from a transportation impact study prepared for the Washington State Legislative Transportation Committee (HDR Engineering, Inc, [HDR], 1999). In the case of Idaho railroads, information about the potential shift of grain to rail was provided to representatives of each of the short-line railroads, with a request that they identify any improvements that might be needed and estimated costs, if any.

Current Conditions, Needs, and Costs. Infrastructure needs of the affected short-line railroads in Idaho and Washington would be relatively more impacted than the mainline railroads. The reason for this is that these rail lines are generally in poor condition at present. The poor condition of the lines stems from the fact that most of the short-line railroads are spin-offs of low volume, low revenue/profit segments of the mainline system, and maintenance tends to be deferred. Traffic on most of the operating short-line railroads is limited to speeds from 25 to 45 miles per hour. Assessments of current needs have been made for both Idaho and Washington and are included in the respective state railroad plans. These analyses identified current maintenance needs amounting to about $21 million. Completion of this maintenance work is needed even if the four lower Snake River dams are not breached.

Incremental Infrastructure Needs with Dam Breaching. To identify incremental improvements that might be needed with dam breaching, representatives of the railroads that would be impacted by dam breaching were contacted and asked to identify any potential additional improvements. In addition, information from other sources was used to identify needed improvements and costs. Needed improvements that were identified include interchanges with mainline railroads, track upgrading, and "other." All of the improvements that were identified were associated with railroads in Washington. To date, no needs have been identified for railroads in Idaho. The cost of the improvements for Washington railroads was estimated to range from about $20 million to $24 million.

Rail Car Capacity

If dam breaching were to occur, approximately 1.1 million tons of grain would transfer to rail. In analyzing available information on current railcar availability and costs, a range of the number of cars needed and their costs was developed. At present there is a large surplus of grain cars. For example, BNSF's grain car utilization rate for June 1999 was only about 50 percent. In spite of this, the analysis for this study is based on the premise that additional rail cars would have to be acquired over the long term to move the grain that would shift to rail with dam breaching. A number of factors were considered in the analysis, including the size of the cars, the turn rate, and the cost per car. The resulting costs ranged from about $14 million to about $37 million.

Rail System Congestion

If dam breaching were to occur, the rail system will experience increased traffic. This increase in traffic has the potential to cause congestion on mainlines and at loading and unloading facilities. Congestion on short-line railroads is not considered likely because those facilities are almost universally only lightly used at present. In the case of congestion at loading and unloading facilities, the DREW Transportation Study Team believes that with implementation of the infrastructure improvements identified in this report there would not be a significant increase in delays due to congestion. In fact, it is likely that the system would become more efficient as it adjusts to a more significant role in the transport of grain within the region. This issue was specifically addressed in the TVA and Marshall University study (TVA and Marshall University, 1998). This study concluded that (1) improvements to the system may be needed to avoid congestion and (2) needed improvements could be made without increasing long-run marginal costs or putting upward pressure on rates. The potential for congestion on BNSF and Union Pacific railroads was also reviewed by transportation analysts at both railroads.

Highway System Requirements

Change in Highway Use

Impacts on highway capital and maintenance cost with dam breaching were determined on the basis of the change in the use of highways to transport grain. The change in highway use was computed as the change in truck miles if dam breaching were to occur. Estimates of the change in truck miles with dam breaching are shown in Table 3.3-16, by state. Also shown is the number of alternative origins/destinations for which truck miles would increase and decrease in each state. These changes range from a decrease of about 1.4 million miles in Idaho to an increase of nearly 3.0 million miles in Washington. The decrease in Idaho is explained by the shift of grain to rail, and the increase in Washington is explained largely by the change in the destination of truck shipments from ports on the lower Snake River to ports in the Tri-Cities area. Maintenance cost savings for Idaho were not estimated, and the change in truck miles for Oregon was considered to be too small to be significant. In the case of Washington, costs include miles for grain movements from Montana and North Dakota because the increase in miles would actually occur in Washington.

Table 3.3-16. Summary of the Change in Truck Miles, by State and the Number of Alternate Origins/Destinations with Increased and Decreased Miles

				Number of Alternate Destinations and Change		
State	**Sum Of Total Bushels**	**Increase in Bushel-Truck Miles**	**Increase in Truck Miles** [1/]	**Miles Increased**	**Miles Decreased**	**Total Alternate Destinations**
Idaho	24,271,500	(1,235,193,157)	(1,419,762)	4	31	35
Oregon	736,804	30,198,573	34,711	1	0	1
Washington	63,407,459	2,577,756,664	2,962,939	11	4	15
Montana*	4,913,924	757,607,372	870,813	6	0	6
N. Dakota**	1,847,743	265,297,487	304,940	1	0	1
Totals	95,177,430	2,395,666,939	2,753,640	23	35	58

Notes:

*Montana is divided into regions.

**North Dakota is a single region.

1/ For this analysis, number of bushels per truck equals 870.

Highway Infrastructure Improvement Needs

Highway improvements that were identified as necessary to maintain adequate highway performance and minimal travel delay include intersection improvements, pavement replacement or overlay, and more frequent maintenance. Total estimated costs for these improvements range from about $84 million to $101 million. An annual increase in accident costs amounting to about $2 million was also estimated (HDR, 1999).

Highway Congestion

Based on an assumption of a truck capacity of 1,000 bushels (30 tons) of grain per truck-load in the highway congestion analyses, with dam breaching there would be an increase of approximately 95,200 truck trips to the Tri-Cities area in Washington. Based on assumptions used for this study, this would result in an increase of 370 average daily truck trips, or about 45 trips per hour. With the implementation of the highway improvements identified in this report, highway congestion should not increase, however, additional, more detailed, engineering and traffic studies would be required to determine what highway improvements would actually be needed.

Elevator Capacity Requirements

With dam breaching, it is projected that about 1.1 million tons of grain would shift from the river to rail. In addition, it is projected that an additional 2.7 million tons of grain would be shifted from lower Snake River ports by truck to the Tri-Cities for barging to ports on the lower Columbia River. Additional storage and handling capacity would be needed at both export facilities located on the lower Columbia River and at river ports in the Tri Cities area.

Rail Car Unloading Capacity at Export Elevators

Analysis of current rail unloading capacity at export terminals showed a total daily capacity of about 85,000 tons (1.7 million tons per month). This amount excludes the new terminal planned at Hayden Island, which will have a capacity of 6 million tons per year or 500,000 tons per month. To determine if existing capacity could accommodate the increased rail shipments of grain with dam breaching, historical monthly rail car unloadings at Columbia River export elevators from 1988 to 1997 were analyzed. Based on this analysis of historic peak monthly volume and expected peak additional volume with dam breaching, the maximum expected demand on rail unloading facilities with dam breaching is estimated to be about 1.6 million tons, which is somewhat less than existing capacity. Based on this analysis, it was determined that no additional capacity would be needed with dam breaching.

Rail Car Storage at Export Elevators

With dam breaching there would be an increase of from eight to nine unit trains per month being delivered to export terminals, or from about 840 to about 940 rail cars. The actual amount of storage required, however, would be significantly less because of the turn rates. The turn rates used in the analysis reduce the number of additional rail cars actually needing storage from a range of 840 to 940 cars to a range of 280 to 670 cars. In addition, assuming an even flow of shipments only about one-half of the cars would be at the terminals for unloading at any one time. The other one-half would be in the process of being loaded. Thus, rail storage at export terminals or on rail sidings in the area would only be needed for about 140 to 325 additional cars. Except at Kalama, a facility that primarily handles corn, rail cars are not stored at the export terminals unless they are actually being unloaded. Loaded and empty cars must be shuttled between the terminals and sidings on a daily basis.

To meet this demand for additional rail car storage, the most likely option was determined to be construction of a single new siding long enough to accommodate the additional cars. The estimated cost of the siding, including track, rights-of-way, turnouts, and control points, ranges from about $2.0 million to $4.1 million.

River Elevators

Grain that would continue to be shipped to export terminals by truck/barge would be trucked to the Tri-Cities area before being loaded onto barges for the remainder of the trip. The estimated volume of grain is about 2.7 million tons (90 million bushels). Analysis of the operating characteristics of river elevators showed that additional capacity needed at the confluence or the Tri-Cities area would range from 10.8 million to 36 million bushels of storage and put-through capacity, depending on the turnover ratio ultimately achieved. Estimated costs for this range of capacity are from about $58.7 million to about $335.4 million, depending the type of facility (barebones or state-of-the-art) and capacity. These estimates include the cost of rail trackage and access roads.

Country Elevators

Based on information obtained from country elevator operators for the SOR and updated for this study, it was determined that capacity at country elevators is adequate. The costs for improvements to upgrade railhead facilities in Washington were estimated to range from about $14.0 million to $16.9 million. Loading and unloading facilities at railhead country elevators in Idaho are considered to be adequate to accommodate the increase in rail shipment without any improvements.

3.3.5.7 Summary—Dam Breaching Condition

Annual NED Transportation Costs

Annualized transportation costs associated with all commodities under the dam-breaching condition are displayed below in Table 3.3-17. Annual costs are shown for discount rates of zero, 4.75, and 6.875 percent, are expressed in 1998 dollars, and are based on a 100-year period of analysis from 2007 to 2106.

Table 3.3-17. Summary of Dam-breaching Condition Total Average Annual Costs—All Commodities, 2007 – 2106 (1998 dollars)

Discount Rate (%)	Average Annual Cost ($)
6.875	235,769,575
4.750	237,674,548
0.000	242,339,125

Adjustment of Annual Costs to the Base Year 2005

Average annual costs in Table 3.3-17 were adjusted to the base year of 2005 to be consistent with analyses of other fish restoration alternatives. This was done by discounting the values for 2007 to 2106 (Table 3.3-17) by 2 years at the appropriate discount rate. The adjusted annual costs are shown in Table 3.3-18.

Table 3.3-18. Annual Costs Adjusted to the Base Year of 2005—All Commodities (1998 dollars)

Interest Rate (%)	Average Annual Costs ($)
6.875	206,411,548
4.750	216,608,063
0.000	242,339,125

Infrastructure Capital Costs

In addition to the annual NED costs shown above, expenditures on transportation infrastructure would also be required to increase the capacity of the system prior to actual implementation of dam breaching. These costs are not part of the cost of the Federal project to breach the four lower Snake River dams, but would be required as a direct result of implementation of dam breaching. Shipping, handling, and storage costs used in this analysis include the amortized capital and operating costs of all of the components of the transportation system. A key assumption in the analysis is that capacity can be added to the system at a cost that is no higher than the cost of the capacity that now exists. On this basis, the annual cost of infrastructure improvements is already embedded in the shipping, storage, and handling costs used in the analysis. Therefore, it is appropriate that infrastructure costs not be included in the estimated transportation costs with dam breaching. A summary of infrastructure improvements that would be needed and estimated ranges of costs are provided below in Table 3.3-19.

Table 3.3-19. Summary of Estimated Costs of Infrastructure Improvements Needed with Dam Breaching (1998 dollars)

	Estimated Costs ($)	
Infrastructure Improvements	**Low**	**High**
Mainline Railroad Upgrades	14,000,000	24,000,000
Short-Line Railroad Upgrades	19,900,000	23,800,000
Additional Rail Cars	14,000,000	26,850,000
Highway Improvements	84,100,000	100,700,000
River Elevator Capacity	58,700,000	335,400,000
Country Elevator Improvements	14,000,000	16,900,000
Export Terminal Rail Car Storage	1,985,000	4,053,000
Total	**206,685,000**	**531,703,000**

3.3.6 Comparison of Base and Dam Breaching Conditions

3.3.6.1 Increase In Transportation Costs of Grain

The increased costs of transporting grain with dam breaching are displayed below in Table 3.3-20. In terms of the cost per bushel, the increase in cost with dam breaching ranges from a high of 21 cents per bushel for Montana to a low of approximately 6 cents per bushel for Oregon. The changes in costs for storage and handling are explained by the increased use of country elevators that have a slightly higher cost than river elevators whose use would decrease if dam breaching were to occur. The change in transportation costs is due to the difference in cost between alternative modes and changes in distance.

Table 3.3-20. Increase in Grain Shipments and Shipping Costs with Dam Breaching for 2007 Projected Volume, by State[1/] (1998 dollars)

State	Grain Quantity	Transportation Cost ($)	Storage Cost ($)	Handling Cost ($)	Total Cost ($)
Idaho					
Cost per Bushel	32,289,941	.153	.02.8	.013	.194
Cost per Ton	969,668	5.11	0.92	0.42	6.46
Total Cost		4,954,984	894,385	410,294	6,259,663
Montana					
Cost per Bushel	6,537,310	.210	0.0	0.0	.210
Cost per Ton	196,139	7.02	0.00	0.00	7.02
Total Cost		1,376,031	0	0	1,376,031
N. Dakota					
Cost per Bushel	2,458,172	.106	0.0	0.0	.106
Cost per Ton	73,753	3.55	0.00	0.00	3.55
Total Cost		261,556	0	0	261,556
Oregon					
Cost per Bushel	980,218	.063	0.0	0.0	.063
Cost per Ton	29,409	2.09	0.00	0.00	2.09
Total Cost		61,328	0	0	61,328
Washington					
Cost per Bushel	84,355,029	.137	.019	.009	.165
Cost per Ton	2,530,904	4.58	0.62	0.29	5.49
Total Cost		11,586,875	1,580,001	737,028	13,903,904
Totals					
Cost per Bushel	126,620,670	.144	.020	.009	.173
Cost per Ton	3,802,423	4.80	0.65	0.30	5.75
Total Cost		**18,240,774**	**2,474,386**	**1,147,322**	**21,862,482**

1/ Costs shown do not include an "adjustment" cost that was calculated by the model to prevent the cost of any movement with dam breaching from being less than it was estimated to be in the base condition. The total regional adjustment amounts to $794,781.

The estimated additional costs for transport of grain as a result of dam breaching were converted to average annual values for the period of analysis from 2007 to 2106. These annual amounts, in terms of totals, cost per ton, and cost per bushel and computed at three different discount rates are displayed in Table 3.3-21. The values shown reflect 1998 price levels.

Table 3.3-21. Average Annual Change in Shipping Costs of Grain with Dam Breaching at Selected Discount Rates[1/] (1998 dollars)

Cost Increase	Discount Rate		
	6.875%	**4.75%**	**0.00%**
Transportation Cost Increase			
Total ($)	18,827,438	18,965,029	19,319,712
Cost per Ton ($)	4.96	4.99	5.09
Cost per Bushel ($)	.1487	.1498	.1526
Storage Cost Increase			
Total ($)	2,553,967	2,572,632	2,620,745
Cost per Ton ($)	0.67	0.68	0.69
Cost per Bushel ($)	.0202	.0203	.0207
Handling Cost Increase			
Total ($)	1,184,223	1,192,877	1,215,186
Cost per Ton ($)	0.31	0.31	0.32
Cost per Bushel ($)	.0094	.0094	.0096
Total Annual Cost Increase			
Total ($)	22,565,628	22,730,538	23,155,643
Cost per Ton ($)	5.94	5.98	6.10
Cost per Bushel ($)	.1782	.1795	.1829
Total Bushels	126,620,670		
Total Tons (33.33 bu/ton)	3,799,000		

1/ Values exclude adjustments calculated by the model to prevent estimated costs with dam breaching from being lower than costs without dam breaching, as follows: 0.00 percent interest, $269,805; 4.75 percent interest, $264,855; and 6.875 percent interest $262,933.

3.3.6.2 Increase in Transportation Costs of Non-grain Commodities

The estimated additional transportation costs of non-grain commodity movements as a result of dam breaching were computed for each commodity group and for the same selected years as those used for grain. As with grain, no additional increase in volume is forecast beyond 2017. These costs are shown below in Table 3.3-22.

Table 3.3-22. Average Annual Change in Shipping Costs for Non-grain Commodities With Dam-breaching, by Commodity Group, and at Selected Discount Rates (1998 dollars)

Year/Commodity Group	Cost Increase ($)
2002	
Petroleum	512,071
Logs and Wood Chips	1,440,861
Wood Products	1,064,591
Other	518,133
Total	3,535,656
2007	
Petroleum	548,456
Logs and Wood Chips	1,440,861
Wood Products	1,274,167
Other	587,610
Total	3,851,094
2012	
Petroleum	584,458
Logs and Wood Chips	1,440,861
Wood Products	1,629,181
Other	683,880
Total	4,338,380
2017	
Petroleum	673,314
Logs and Wood Chips	1,440,861
Wood Products	2,064,593
Other	790,595
Total	4,969,363

The estimated additional transportation costs of non-grain commodity movements were also converted to average annual values for the period of analysis from 2007 to 2106. These annual amounts, computed at three discount rates, are presented in 1998 dollars in Table 3.3-23.

Table 3.3-23. Average Annual Change in Shipping Costs for Non-grain Commodities With Dam Breaching (1998 dollars)

Discount Rate (%)	Average Annual Cost ($)
6.875	4,623,910
4.75	4,709,693
0.00	4,904,266

3.3.6.3 Increase in Transportation Costs — All Commodities

Table 3.3-24 presents the average annual increase in shipping costs that would result if dam breaching were to occur. This increase presented at three discount rates addresses both grain and non-grain commodities. These costs include the adjustments referred to in Table 3.3-21, footnote 1.

Table 3.3-24. Average Annual Shipping Cost Increase for All Commodities (1998 dollars)

Discount Rate (%)	Average Annual Cost ($)
6.875	27,452,471
4.750	27,705,085
0.000	28,329,717

3.3.6.4 Adjustment of Annual Costs to the Base Year

Average annual costs in Table 3.3-24 were adjusted to the base year of 2005 to be consistent with analyses of other economic impacts. This was done by discounting the values for 2007 to 2106 (Table 3.3-24) by 2 years at the appropriate discount rate. The adjusted annual costs are shown in Table 3.3-25.

Table 3.3-25. Average Annual Cost Increase—All Commodities, Adjusted to the Base Year of 2005 (1998 dollars)

Discount Rate (%)	Average Annual Costs ($)
6.875	24,034,173
4.750	25,249,421
0.000	28,329,717

3.3.7 Risk and Uncertainty

3.3.7.1 Sources of Risk and Uncertainty

The dam breaching alternative raises a considerable amount of uncertainty with regard to the magnitude of economic and/or financial impacts that could potentially be experienced with plan implementation. One primary area of uncertainty as it relates to dam breaching is the capability of the existing transportation system to adjust to accommodate the types of changes among modes and routings that are projected with river closure. A second area of uncertainty is the magnitude of financial impact that may be experienced by producers and shippers of commodities given the extensive transformation that would occur within the transport sector of the Pacific Northwest. Issues of risk and uncertainty include concerns about system capacity, the cost of improvements that may be needed, potential transportation rate impacts, impacts to roads and highways, and impacts on the rail system. To address the potential impacts of these and other related issues, several sensitivity analyses were developed in an attempt to identify the range of additional economic and financial costs that could potentially be experienced with river dam breaching. Following is a list of risk and uncertainty sources addressed in the DREW Transportation System Impacts Analysis Report, 1999. In addition, the sensitivity to the transportation model to alternative assumptions was assessed. A summary of this assessment is presented below in Section 3.3.7.2.

Sources of risk and uncertainty that were assessed during the study:

- Capacity
- Railroad
- Export elevators
- River elevators
- Roads and highways
- Modal rates
- NED efficiency loss with monopoly increase in rates
- Transportation system reliability
- Construction of a petroleum pipeline
- Grain forecast
- Potential impacts on the export market for grain
- Duration of transition to equilibrium with dam breaching
- The incidence of infrastructure costs.

3.3.7.2 Sensitivity of Model Results to Input Values and Assumptions

The ACCESS database model used for the analysis of transportation system costs required a number of assumptions and estimated input values. Modifying any of these assumptions would change the results produced by the model. Key assumptions and input values used in the model were reviewed, and effects of the use of alternative assumptions and values were determined. The review, however, was limited to a qualitative assessment. An attempt at establishing probable ranges of values was not made, nor were additional model runs made using alternative assumptions. Summary results of the review and assessment are presented in Table 3.3-26.

3.3.8 Unresolved Issues

3.3.8.1 General

There are a number of unresolved issues relating to the analysis, especially the modeling of the transportation system with and without dam breaching. These issues are identified and briefly described below.

3.3.8.2 Commodity Forecasts

Commodity forecasts used for the analysis were developed from forecasts of commodity movements on the lower Columbia River deep-draft navigation channel. These forecasts were developed for the Corps'

Table 3.3-26. Qualitative Assessment of the Effect of Using Alternate Assumptions and Input Values in the Transportation Analysis Model

Variable and Existing and Alternate Assumptions	Effect on Model Results
Base Commodity Level • Assumption: Base commodity levels used are for 1996. • Alternate Assumption: Use 1997 levels.	• The assumption used results in a higher base volume for grain than if the volume for 1997 were used. If the volume in 1997 is representative of the future, the impact of dam breaching is overstated (1997 grain shipments decreased by about 20 percent from 1996). • Use of 1997 as the base would decrease the total volume of grain in the system, and the amount that would be affected by dam breaching. This would reduce the estimated increase in cost by a proportional amount: i.e., by as much as 20 percent. If 1997 shipments are a deviation from the norm, rather than the basis for a new trend, this would understate long-term impacts of dam breaching.
Commodity Forecast • Assumption: Forecasts were derived from forecasts developed for the Columbia River Channel Deepening Study. In the context of Snake River shipments, these are demand-based forecasts. • Alternate Assumption: Develop forecasts specific to Snake River by analysis changes in production by commodity group.	• The accuracy of the forecast used depends entirely on the accuracy of the forecast developed for the Columbia River Channel Deepening Study. The effect on model results is unknown without development of an alternate forecast. Costs for grain are not sensitive to the forecast at the per-ton or per-bushel level. • The alternate forecast methodology would link the forecast directly to production in the Snake River hinterland. As a result, such a forecast might be more defensible. It is not possible to predict whether this forecast would be higher or lower than the forecast used.

Table 3.3-26. Qualitative Assessment of the Effect of Using Alternate Assumptions and Input Values in the Transportation Analysis Model

Variable and Existing and Alternate Assumptions	Effect on Model Results
Commodity Origins • Assumption: Origins for grain are at the county level, except for Montana (six regions) and North Dakota (one region for the entire state). Origins for non-grain commodities (except farm commodities) are specifically defined. • Alternate Assumption: Expand the model to include greater detail.	• Distance for farm direct to river or rail is computed from the center of the origin county. Distance is not computed for farm to country elevator movements. Accuracy of the cost estimates is reduced for grain and other farm commodities. • The level of detail could be expanded at the farm level. This would improve accuracy and would allow all transportation costs to be estimated. Modeling cost would be much higher.
Storage Costs • Assumption: Storage costs are charged at country elevators and at river elevators. Duration of storage is the same. Average costs are used for each type of facility. • Alternate Assumption: Base storage duration and costs depend on actual industry practice, including shipments during harvest that do not require harvest.	• The assumption that river elevators are used for long-term storage is questionable. Also, the assumption that all grain is stored is questionable. The assumption almost certainly overstates storage costs. • This would increase the accuracy of the model. It would require more detailed data on storage costs by type of facility (river, country, and railhead) and inclusion of a demand function in the model. Revisions would improve the accuracy of the model, and estimated costs would be expected to decline.
Handling Costs • Assumption: Handling costs are charged at each facility through which grain moves, except at export elevators. Costs used are for river elevators and country elevators. Costs at railhead facilities are assumed to the same as for other country elevators. Costs at export terminals are assumed to be the same for rail and barge shipments. • Alternate Assumption: Develop and include estimates of handling costs for all types of elevators for both rail and barge modes in the model.	• Assumptions that handling costs at railhead facilities are the same as at country elevators and that handling costs at export terminals are the same for rail and barge shipments are probably incorrect. Handling costs may be overestimated or understated. • This would provide for a greater level of detail and would change estimated costs, but the direction of the change is not certain.

Table 3.3-26. Qualitative Assessment of the Effect of Using Alternate Assumptions and Input Values in the Transportation Analysis Model

Variable and Existing and Alternate Assumptions	Effect on Model Results
Transportation Costs • Assumption: Reebie model estimates of modal costs are used. • Alternate Assumption: Use existing rates in the model.	• Reebie model estimates may contain errors in both truck and barge costs. Truck costs appear to be high, and barge costs may be low. Correction of the errors is needed. Since costs tend to be lower than rates (except for long-haul truck), use of costs reduces estimated impacts of dam breaching. • Use of rates would modify estimated changes in modal shift of grain and costs. Truck rates are lower than estimated costs, so use of rates would decrease cost impacts. Rail costs are slightly lower than rates, so use of rates may not change the result by a significant amount. Barge rates are much higher, relative to costs, than rail rates, so their use would make rail a much more attractive alternative and would reduce the estimated cost impact of dam breaching.
Elevator Capacity • Assumption: The model does not include capacity or a capacity constraint. • Alternate Assumption: Include a capacity function in the model.	• The absence of a capacity function in the model does not allow for analysis of system capacity requirements or identification of potential capacity constraints at specific locations. This may lead to underestimating capacity requirements. • To be very useful, the capacity function would have to be elevator-specific, and alternative routings of grain movements in the event of a capacity constraint would have to be included in the model. This type of optimization model would greatly improve the accuracy of assessment of capacity needs with dam breaching, but would require a significant data gathering and modeling effort.

Table 3.3-26. Qualitative Assessment of the Effect of Using Alternate Assumptions and Input Values in the Transportation Analysis Model

Variable and Existing and Alternate Assumptions	Effect on Model Results
Seasonality of Shipments • Assumption: The model does not include a demand function. • Alternate Assumption: Include a demand function in the model.	• The capability of the system to meet seasonal fluctuations in grain shipments was assessed by examining the peak historic single-month demand adjusted to what it would be with increased rail shipments. This showed that there is sufficient capacity. A number of factors could cause this estimate to be either high or low. • Including a demand function in the model could potentially identify grain-handling constraints at hinterland and terminal elevators. Accurate modeling would require detailed data on handling capacity of all elevators, including rail car handling and unloading. This would require a significant modeling effort, and it would be difficult because of the numerous variables to consider. The effect on model results is not predictable.

study of the feasibility of deepening the deep-draft channel from Portland to the ocean. The forecasts developed for this study were obtained by simply prorating the forecast for the lower river to the Snake River on the basis of the Snake River's historic share of shipments on the lower Columbia River. Arguments have been made that this type of forecast is inappropriate because it does not actually include consideration of sources of commodities in the Snake River hinterland.

3.3.8.3 Modeling Logic and Use of Adjustments

The transportation system model is based on the logic that the current pattern of commodity shipments reflects shippers preferences and, in general, is representative of a must be an optimized least-cost system. On this basis, modelers designed the model to prevent the cost of any commodity movement from being lower with dam breaching than it was without dam breaching. The modeler's objective was accomplished by including an adjustment in the model that is equal to the difference between the cost of commodity movement with dam breaching and the cost without dam breaching. If the cost of the movement with dam breaching is lower than it was estimated to be without dam breaching, the difference is added to the estimated cost with dam breaching, thus making the costs the same for both conditions.

The IEAB questions the validity of the use of the adjustment on the basis that it distorts the results of the modeling effort. They point out that all models are extractions from reality and that it is inappropriate to make adjustments to try to make them match reality. In the case of the DREW model, there are a number of reasons why the model would show lower costs for some movements with dam breaching than without dam breaching. First and foremost is the fact that some people do things for other than economic reasons. This kind of non-economic behavior cannot be captured in a model. Secondly, the problem could be due to errors in the model: i.e., errors in transportation, storage, or handling costs. The IEAB has stated that the adjustment should be deleted from the model. The effect of doing so would reduce the net difference between the with and without project conditions.

3.3.8.4 Truck Costs

Truck costs used in the transportation system model are significantly higher than truck costs estimated for the Corps in a study by the Upper Great Plains Transportation Institute. A preliminary review of Reebie Model truck costs for a sampling of movements showed that there is an error in the way driver costs were calculated, making them much higher than they apparently should be. For example, the UPGTI study reported a total allocated cost for long-haul truck movement of grain of $1.04 per mile, with a driver cost of $0.29 per mile. By comparison the cost for one movement of 870 miles (round-trip) in the transportation system model has a cost of $2.716 per mile, with a driver cost of $1.315 per mile. Correction of errors in truck costs used in the model would significantly lower the cost of truck movements of commodities and could change (decrease) the volume of grain that is predicted to shift to rail with dam breaching.

3.3.8.5 Barge Costs

There is a significant variation between barge costs as estimated by the Reebie Barge Model and rates that are actually charged by the barge industry. For example, the cost estimated by the Reebie Model for shipping grain from Almota, Washington, to Portland, Oregon is $3.07 per ton compared with the actual rate charged by the industry of about $6.07 per ton. Industry representatives have stated on numerous occasions that the costs estimated by the Reebie Barge Model are incorrect (too low). In response to the comments by representatives of the barge industry, Corps analysts reviewed three other studies of barge costs. The finding was that all of the studies indicated that rates are significantly higher than costs. In addition, input data for the Reebie Model were provided to an industry representative for review and comment. That review has not been completed. If barge costs are in fact higher than the Reebie Model costs used in the transportation system model, use of actual costs in the model would tend to offset the effect of reducing truck costs as described above.

3.3.8.6 Storage and Handling Costs

Model estimates of storage and handling costs for grain shipped to the Northwest from the states of Montana and North Dakota amount to nearly $6.50 per bushel. This is almost double the market value of wheat and clearly is not representative of the long-run equilibrium condition that the model is supposed to represent. Corps modelers are aware of this problem and, in fact, have corrected it, however, revised model results were not available for inclusion in the draft report. For the draft report, it is important for readers to understand that the error has no effect on the primary objective of the model—to estimate the change in costs with dam breaching—because these costs are the same with and without dam breaching.

Another issue concerning storage and handling costs is the use of “rates” rather than costs. In this regard, the model is inconsistent because costs are used for alternative transportation modes, whereas rates are used for handling and storage. One effect of the use of rates is that the model uses the same handling rate for rail and barge shipments at the downriver export terminals. This is consistent with actual practice because the terminals do in fact charge the same handling rate for both rail and barge shipments. Industry representatives have, however, stated that handling costs for rail shipments are actually about 40 percent higher than for barge shipments.

3.3.8.7 NED Effects of Redirected Cross-River Road Traffic

The Lower Monumental Dam is the connecting link between Lower Monumental Road (south side) and Devils Canyon Road (north side), and the Lower Granite Dam is the link between Lower Deadman Road (south side) and Almota Road (north side). Alternate routes are Washington 126 that crosses the river at Lyons Ferry and Washington 127 that crosses the river at Central Ferry, respectively. Use of the alternate routes could increase overall travel distance for users, depending on their origin and destination. While the other two dams, Ice Harbor and Little Goose, have road crossings, they do not appear to link major state or county roads and so appear to be primarily used by project operators and tourists. The IEAB has stated that the NED effects of severing the roadways that are linked by the Snake River dams should be quantified.

3.3.8.8 Inconsistency in Truck Long-Haul Distances

The transportation system model defines long-haul truck movements of grain as movements of 150 miles or more, and it uses a cost that is based on the availability of a two-way haul (backhaul). However, the study conducted for the Corps by the Upper Great Plains Transportation Institute found that the break between short-haul (local market) and long-haul-truck movements is 250 miles. This distance was defined on the basis of the finding that this is the distance where rail shipment of grain becomes competitive with truck shipment. The UGPTI study further found that long-haul truck shipment of grain only occurs in the presence of two-way haul opportunities. This finding is consistent with modeling done by the Corps that assumes the presence of backhaul for all long-distance (150 miles or more) truck shipments of grain. The IEAB has stated that there should be consistency in long-haul assumptions between the two studies.

3.3.8.9 Continued Use of Existing Snake River Elevators With Dam Breaching

With dam breaching and closure of the Snake River to barge traffic, 12 river elevators could become abandoned. In 1998 these facilities handled a combined total of over 100 million bushels of grain (Tidewater Barge Lines, Inc., July 1999). With dam breaching, the alternate river port becomes the Tri-Cities area. Construction of replacement facilities in the Tri Cities could cost over $300 million. A less costly alternative may be to continue using some of the existing facilities as railroad loading facilities. In particular, the location of the facilities at Central Ferry might make them an attractive railhead alternative. Additional study would be needed to determine if conversion of these facilities to a railhead would lower overall costs.

3.4 Water Supply

3.4.1 Introduction

This report focuses on the evaluation of Snake River water users and the potential effects to these groups as a result of actions to improve anadromous fish returns. Although there are four different alternatives under consideration to improve anadromous fish returns, only Alternative 4, Dam Breaching, would directly affect the operation of river pump stations and wells used for irrigation and other purposes.

Irrigation water for farm purposes is the dominant consumptive use of the water pumped from the river. Other potentially impacted water user groups that are included in the following analysis are municipal and industrial (M&I) pump operators and private well users.

Section 3.4.2 of this analysis focuses on effects to irrigated agriculture. Section 3.4.2.1 provides a description of irrigated agriculture in Franklin and Walla Walla Counties and Section 3.4.2.2 describes more specifically the farms that withdraw water from the lower Snake River at the Ice Harbor reservoir. Three separate approaches to measuring the economic effect to irrigators under dam breaching conditions are included. Section 3.4.2.3 describes the economic effects based on the modified cost approach. Section 3.4.2.4 indicates the economic effects based on the change in farmland values under dam breaching. Whereas Section 3.4.2.5 provides an estimate of economic effects based on the change in net farm income. Conclusions about the effect of dam breaching on irrigated agriculture are presented in section 3.4.2.6.

Section 3.4.3 of this report discusses the effect on other water users, particularly users of municipal and industrial (M&I) pumps and privately owned wells. The required modification costs to M&I pump stations and private wells provide the measurement of the economic effects to these other water users.

Section 3.4.4 of this report summarizes the economic effects to water users. Section 3.4.5 describes the sensitivity analysis of the economic effects to irrigated agriculture.

Basic Assumptions

- The economic analysis of water supply effects relied heavily on existing studies and data. In general, the analysis of economic effects was primarily limited to estimating the capital costs of system modifications. The rationale for the limits on the analysis were that the data from existing studies appeared reasonably good, net farm income analysis would be an extensive and expensive effort with probable limited returns, and relative to other NED costs water supply effects are small. For instance, under dam breaching conditions the total water supply NED effects are less than 10 percent of the hydropower costs.

- Irrigated farmland operators that currently pump water from the Ice Harbor Reservoir will no longer be able to pump water from the reservoir under dam breaching conditions, and the value of the impacted 37,000 acres of farmland would be reduced to non-irrigated grazing land. This change in farmland value represents the economic effect of dam breaching on pump irrigators.

- Economic effects under dam breaching conditions to municipal and industrial pump station operators and privately owned well users are determined by estimating the system modification costs.
- The economic effects to water users that are described in this report would be incurred the year that dam breaching is implemented.

3.4.2 Irrigated Agriculture

3.4.2.1 Profile of Irrigated Agriculture, Franklin and Walla Walla Counties

The counties of Franklin, Walla Walla, Whitman, Columbia, Garfield and Asotin in Washington and Nez Perce County in Idaho border the four lower Snake River reservoirs. However, this water supply analysis focuses on only those portions of the counties that are served by water from the four reservoirs or would be impacted by changes in these reservoirs.

Of the counties listed above irrigated agriculture is dominated by Franklin and Walla Walla. The very large river pumping stations used for irrigated farming that would most directly be impacted under dam breaching conditions are located in these two counties. Irrigation water is withdrawn from both the Columbia and Snake Rivers out of the McNary and Ice Harbor pools, respectively. However, this analysis is concerned with the lower Snake River water users located near Ice Harbor reservoir in the counties of Franklin and Walla Walla.

Since the construction of Ice Harbor Dam in the early 1960s, private entities have financed the development of infrastructure necessary to grow irrigated crops in the region. The majority of the irrigated farmland adjacent to Ice Harbor reservoir is irrigated by pumping water from the Snake River. Some additional land is irrigated using wells.

A review of irrigated acreage information from several sources indicates that there are about 37,000 acres using pumped Snake River water at Ice Harbor reservoir. The Columbia River System Operation Review study that was completed in 1995 identified 36,400 acres of irrigated farmland using Snake River water pumped out of Ice Harbor reservoir (Corps, 1995). A recent inventory effort completed by Corps of Engineers, Portland District economists documented about 34,000 acres of irrigated cropland using water pumped out of Ice Harbor. Although specific documentation is not readily available some local agriculture experts indicated that they believe the actual number of acres irrigated with water pumped from Ice Harbor is somewhat greater than what the above estimates indicate. For instance, the Natural Resources Conservation Service (NRCS) regional field office estimated that there are over 50,000 acres of irrigated farmland adjacent to Ice Harbor. However, a breakdown between the acres irrigated with pumped water and well water was not provided. Consequently, it is surmised that a substantial amount of this additional acreage is irrigated using well water.

For purposes of analyzing the economic effects to pump irrigators under dam breaching conditions, it is estimated that approximately 37,000 irrigated acres in Franklin and Walla Walla counties would be impacted. Table 3.4-1 compares the statewide number of irrigated acres with these two counties. In addition, the table displays the number of acres of specific crops within these two counties.

Table 3.4-1. Acres by Crop Type: State of Washington Compared to Franklin and Walla Walla Counties

Crops	State of Washington Acres	Franklin County and Walla Walla County Acres	Two County Percentage of State Total (%)
Total Irrigated Acres	1,705,000	318,281	18.7
Field Corn	170,000	33,400	19.7
Potatoes	161,000	55,500	34.5
Asparagus	23,000	13,000	56.5
Peas	42,200	5,900	14.0
Onions	13,400	4,600	34.3
Sweet Corn, proc.	75,300	18,400	24.4
Apples	142,000	9,400	6.6
Cherries	14,000	1,700	12.1
Vineyards	31,000	2,300	7.4

Source: Washington Agricultural Statistics, 1996-1997, Washington State Department of Agriculture. U.S. Census Bureau, 1997 (Agriculture).

Comparing the number of irrigated acres that would be impacted by the breaching of Ice Harbor dam to the total amount of irrigated acres within the two counties and statewide show that the quantity of impacted farmland is relatively small percentage. The 37,000 acres represents about 12-percent of the irrigated farmland in Franklin and Walla Walla counties and about 2-percent of the irrigated farmland in Washington State.

Information in Table 3.4-1 also shows the relative importance of specific crops in these two counties compared to the state total. Both Franklin and Walla Walla counties are important field corn producers, together accounting for a fourth of the state's production in 1995. Potatoes are an important crop as well. Franklin and Walla Walla counties contribute to the state harvest significantly and comprise about a third of the state production. Both Franklin and Walla Walla counties also have a lot of acreage devoted to vegetable crops, including asparagus, carrots, peas, onions and sweet corn. Some vegetable crops are found on farms that irrigate from the Ice Harbor reservoir, however the total acreage is not large. Both Franklin and Walla Walla counties have significant acreage in orchards for the production of apples, cherries and grapes as well. A fairly large amount of orchard crops are also grown on farmland adjacent to Ice Harbor reservoir.

3.4.2.2 Profile of Irrigated Agriculture at Ice Harbor Reservoir

This section provides information about non-Federal agricultural water users who pump from the Ice Harbor reservoir.

It has been determined, based on a survey of farms that at least 37,000 acres of land are presently irrigated with water pumped out of Ice Harbor reservoir. Table 3.4-2 summarizes information about the pumping stations that are used to withdrawal Snake River water for agricultural purposes. Data about the farm operations indicate that some additional acreage is irrigated using wells rather than the Snake River pumps. For instance, one of the orchard operators has more horsepower than the river station pumps, and total irrigated acreage is considerably greater than the amount identified in

Table 3.4-2. Changes to the economics of the pump irrigated land component of these farms may directly impact the economic viability of the land that relies on wells. It was, however, assumed for this study that as long as irrigation water is available the land remains economically viable.

Table 3.4-2. Crop Data for Agricultural Pumpers from Snake River, 1996/1997

Pump Stations (Ref. No.) 1/	Total Acreage	Total Acreage Irrigated from Snake	Primary Crops	Notes
IH-1	1,500	1,500	Sweet corn, onions, potatoes	Shared ownership with IH-12
IH-2	4,500	4,500	Hybrid cottonwood	Land/station leased
IH-3	12,000	9,500	Potatoes, wheat, field corn, onions, sweet corn	
IH-5	4,100	4,100	Hybrid cottonwood	Land/station leased
IH-6	5,000	2,200	Field corn, wheat, potatoes	
IH-7	2,900	2,700	Grapes, apples	
IH-9	540	540	Apples	Shared station with IH-10
IH-10	4,000	1,800	Apples, cherries	
IH-11	6,017	4,008	Apples and cherries, sweet corn, potatoes, wheat, peas, field corn	Includes 1000 acres of orchards
IH-12	900	900	Field corn, potatoes, asparagus, wheat	Owns 30% of IH-1 station
IH-16	600	320	Apples, cherries	
IH-17	1,200	1,200	Potatoes, onions	
IH-18	225	165	Vineyards, apples	
IH-19	500	500	Not determined	Future station
ICE HARBOR TOTAL		**33,933**		

1/ This numbering system matches the numbering used in an earlier water supply analysis developed for the Corps (Anderson-Perry, 1991). Pump stations 1H-4, 1H-8 and 1H-13 through 1H-15 are not included in this table because water pumped via these stations is not used for agricultural production.

Source: Survey of Farms, 1997/1998.

Only a portion of the acreage is in permanent crops like fruit tree orchards or vineyards, and, therefore, acreage by crop varies from year to year as crops are rotated. Potatoes, for example, are grown on the same land only one year in three or four for disease control. An estimate of farmland relying on Ice Harbor water by crop type is presented in Table 3.4-3.

Table 3.4-3. Estimated Percentage of Crops by Type

Crop	% of Crop Types
Cottonwood/Poplar	23.2
Potatoes	14.9
Field Corn	13.5
Fruit Tree Orchards	11.1
Wheat	9.5
Vineyards	6.2
Sweet Corn	5.4
Onions	3.0
Undefined Percentage	13.2
Total (37,000 acres)	100

Primary Source: Survey of Farms, 1997/1998.

As Table 3.4-3 shows, cottonwood is the largest crop in percentage terms and is grown for pulp and paper production. Potatoes are the next biggest crop although this will vary year to year. Fruit tree orchards and vineyards are high valued crops, and recently the number of acres has been expanded primarily due to the planting of apple trees in the last two years. Also, a relatively minor amount of acreage is in asparagus, peas and other crops.

Table 3.4-4 summarizes river station pump plant data on size and output for these farms. There are about 75 pumps with a total of about 42,000 horsepower. This does not include booster pumps that are situated between the river station and point of use at a higher elevation than the river station. Electrical usage is for 1996 except for IH-2 and IH-5, and IH-16. Those data are for 1997. Table 3.4-4 was developed using information from a previous consultant's report (Anderson Perry, 1991), Walla Walla District engineers data, and farm manager interview data.

3.4.2.3 Economic Effects: Pump Modification Cost Approach

Introduction

The objective of the analysis of irrigation water users is to estimate the net economic losses under dam breaching conditions as compared to the base condition. A total of three different approaches are presented in this report. These are the pump modification cost approach, the farmland value approach, and the net farm income approach. The pump modification cost approach discussed in this section of the report is the estimation of the cost to modify or replace river pump stations so that the current water supply capability is maintained under dam breaching conditions.

The estimated modification costs discussed below provide an upper bound estimate of the economic effects to irrigators under dam breaching conditions. This approach to measuring the economic effects to irrigators is not intended to imply such investments are necessarily cost effective when compared to farm production and income. The true NED costs would be no greater and may be less than the cost to continue to provide equivalent quantities of water. That is, the farmer can always limit cost increases to the cost of modifying the pumping station (and higher O&M costs) but may be able to do better by changing crops, production techniques, etc.

Table 3.4-4. River Station Pump Plant Data, Ice Harbor Reservoir

Pump Stations (Ref. No.)[1/]	River Mile	Number of Pumps	Horse-Power	Head (ft)	Electrical Usage	Water Usage a-f (yr)	Notes
IH-1	12	8	2,650	360	$217,000	7,917 (95)	Station 30% by IH12
IH-2	12	5	4,500	260	11,000,000 kW	14,000 (97)	
IH-3	17	11	13,500	460	$941,000 30,636,500 kW	29.5 in/ac average	
IH-5	12	5	4,700	260	9,000,000 kW	8,800 (97)	
IH-6	14	8	2,260	260	$112,440 4,591,000 kW	4,341 (96)	
IH-7	12	9	4,900	462	$229,688	12,216 (96)	
IH-9		6					Shared with IH-10
IH-10		8	4,400	410	$234,195	NA	
IH-11	20	6	3,900	310	$182,607	7,275 (96)	
IH-12	12			415	about $72/ac	23 in/ac average	
IH-16	10	2	300	360	330,000 kW	2 af/acre (97)	Water usage will increase when trees mature
IH-17		4	1,300	350	$133,000		
IH-18		2	240	230		18 in/ac	
IH-19		1	125	6			Planned Station

1/ This numbering system matches the numbering used in an earlier water supply analysis developed for the Corps (Anderson-Perry, 1991). Pump stations 1H-4, 1H-8 and 1H-13 through 1H-15 are not included in this table because water pumped via these stations is not used for agricultural production.

Source: Anderson Perry, 1991 and Survey of Farms, 1997/1998.

Initially, the modification cost approach was to be the only analysis applied to measure the economic effects to water users under dam breaching conditions. As a result of significant increases in the estimated cost to modify the pump systems, the study group determined that the modification cost approach overstated the economic effects and additional economic analysis was warranted.

Sections 3.4.2.4 and 3.4.2.5 of this report describe the other two approaches used to assess the economic effects to Ice Harbor water users. As is shown later in this document the high cost to modify the pumping system makes the farmland value approach summarized in section 3.4.2.4 the most reasonable (least cost) estimate of economic effects to Ice Harbor water users.

The remainder of this section of the report summarizes the pumping station modification costs.

System Modification for Dam Breaching Conditions

Three significantly different options to supply equivalent water quantities were identified and considered. Each option is briefly described below. For additional details, refer to Technical Appendix D-Natural River Drawdown Engineering and Technical Appendix E-Existing Systems and Major System Improvements Engineering.

Important requirements of an acceptable modified irrigation system are that the system will be: operational prior to breaching of the Ice Harbor reservoir dam; function through a full range of river stages without interruption; and able to handle a potentially large quantity of suspended sediment.

Under current conditions, the pump stations withdraw water from the Ice Harbor reservoir and pump the water uphill several hundred feet to the individual farm distribution systems. The majority of pumps are vertical turbine type. Without the pool of water created by the Ice Harbor dam, the pumping station intakes would be completely out of the water. Following are the modified systems that were considered.

Option 1

The first option, investigated conceptually in at least one previous study, is to modify each existing pump station by extending pipes and installing additional or bigger pumps according to increases in lift requirements (Anderson-Perry, 1991).

It was initially thought that this approach would function similar to the existing system and minimize the extent and cost of modifications. Unfortunately, during the review of this concept, the engineering study team identified a number of technical concerns. The team was not able to identify acceptable locations to place the new pump stations that would work with the fluctuating and meandering river conditions under dam breaching conditions. This stretch of the river has a wide, flat bottom with substantial silt, sand, and gravel deposits, and as the material erodes under dam breaching conditions, the river would likely meander and affect the availability of water at the pump stations. In addition, erosion at the pump stations could undermine the pump, piping, and intake structures. The engineering study team also indicated serious concern about how the sediment could be managed at many of the locations new pump stations would need to be established. Another issue raised by the team is the technical problems with constructing this new system without causing some interruption in irrigation water deliveries. Any untimely interruption of irrigation water would severely impact permanent crops such as orchard and vineyards.

Option 2

Replacement of river stations with groundwater sources is the second option that was considered. Based on discussions with Dr. Robert Evans, irrigation specialist in the County Extension office in Prosser, Washington, this does not appear to be a feasible option. Wells present numerous problems. There would likely be difficulties in receiving Department of Ecology approval. These wells would need to be drilled deep, increasing both first costs and operating costs. Additionally, the well water would require treatment in order to counter high pH levels; and high sodium content in the well water could lead to soil sealing problems. There is also concern that this system could not be installed without some interruption in irrigation water deliveries, and the interruption of irrigation water deliveries would severely impact permanent crops such as orchard and vineyards.

Option 3

After consideration of options 1 and 2, the study team focused its efforts on a third approach that they determined would technically work and would satisfy the other criteria noted above. This option includes one large pumping station and distribution system with a sediment basin. This system would provide water via a single river pump station and the water would be delivered to each farm through a main pipeline distribution system. Each farm level pump would also require modifications in order to connect to the main pipeline distribution system. A sediment basin/reservoir is included as a component of the one large pump station system because it is anticipated that sediment effects will be significant

Locating the pump station at a narrow point in the river reduces problems with river fluctuation and meandering. Under dam breaching conditions, the water levels would still be deep in this stretch of the river and the rock channel would ensure that erosion would not impact the availability of water for pumping. Another advantage of this one pump station system is that sediment problems can be addressed using only a single sediment control basin.

Option 3 was selected to carry forward in this analysis because it avoids the problems and uncertainties associated with the others. In other words, option 3 was the only approach that the engineering study team agreed would technically work. Some additional discussion of the selected modification system follows in the next subsection. For additional details, refer to the Engineering Appendices (Technical Appendices D and E).

Description and Costs Associated with the Modified Irrigation System

The selected irrigation system to quantify economic costs under dam breaching conditions is a pressure supply system that will withdraw water at one river location (option 3). The primary irrigation system consists of six main components: the pumping plant at the river; the pipe network; connections to existing irrigation systems; secondary pumping plants; a control system; and a sediment control reservoir.

Pumping Plant

The intake structure would be divided into five bays with a peak capacity of 850 cubic feet per second (CFS). Three 1500 horsepower (HP) and two 600 HP vertical turbine pumps would be secured above each of the five bays. Electrical switchgear, valves to allow each pump to be isolated from the system for maintenance work, and appropriate screening would be included.

Pipe Network

The pipeline network would be epoxy lined and polyethylene coated steel pipe. The pipeline would begin at the pump station near river mile 20 on the south shore of the Snake River, and would be 12 feet in diameter at the main pumping plant. The pipeline would then extend downstream about 5,200 feet at which point a branch of the system would cross the river. The branch of the pipe network would cross the river 2700 feet to Emma Lake and then continue another 4,500 feet to the existing pump station at IH11. The main pipeline would extend along the south shore of the lower Snake River for approximately 47,500 feet with branches as needed to connect the other stations to the main pumping plant.

Existing Irrigation System Connections, Secondary Pumping Plants, Control System

Two of the existing pumping plants are multi-pump configurations that would require reconfiguration in order to connect to the pipe network. Several of the existing pumping plants would require manifolds to be constructed and installed to connect each pump to the piping network. Additionally, at each existing and secondary plant, isolation valves would be required to allow for individual plant maintenance. Flow meters would also be installed. It is anticipated that about six air release/vacuum valves would be required for the system. Drain valves and discharge piping would be required to allow the pipeline to be drained. At each branch pipe and each significant directional change in the pipe network, concrete thrust blocks would be used to control potential thrust damage.

Sediment Control Reservoir

The construction of a reservoir addresses sediment concerns and surge control. The reservoir would be a holding pond with approximately 14,000 acre-feet storage which would be required to detain the water sufficient time for the settling of suspended solids.

In order for the modified irrigation system to be functional in time for use by irrigators, construction of the river intake, the pipeline network, and the reservoir would need to be initiated 18 months in advance of dam breaching.

Total construction costs for option 3, the large pumping station with a sediment reservoir, are summarized in Table 3.4-5. The total construction costs are equal to $291,481,000.

The modified agricultural pump system will likely result in increased energy and other operation and maintenance expenses as well. Additional lift of the irrigation water with new pumps or the conversion of existing pumps will result in higher operating costs. Specifically, the greater horsepower will increase the cost of power to the water user. Additional equipment may also require greater maintenance expenditures and may increase the future replacement costs.

Increased maintenance necessary to treat sediment-related problems, even with a sediment control reservoir in place, is not easily predictable. Replacement of worn parts of pumps, valves, sprinklers, and filters may initially be significant.

Therefore, the extent of increased operation and maintenance (O&M) expense associated with the modified irrigation system is not fully understood. Information documented in the Anderson Perry study (1991) is used as a placeholder value because no specific estimate of the additional O&M costs was completed. That study identified additional O&M expenses associated with modifying the existing pump stations equal to $3,573,000/year (1998 dollars).

Construction costs are estimated to equal $291,481,000 with the added O&M expenses associated with the modifications to the irrigation pump stations at Ice Harbor reservoir equal to $3,573,000/year. The estimated modification cost provides an upper bound measurement of the economic effects to irrigators; and the true NED costs would be no greater than this estimate.

Table 3.4-5. Cost Estimate of Modifying Ice Harbor Agricultural Pumping Stations, 1998 Dollars

Component	Construction Costs ($)	
Mobilization, Demobilization & Prep.	11,896,148	
Earthwork for Structures	5,207,616	
Utilities	6,997,734	
Access Road	4,849,592	
Pipelines	71,865,100	
Pumping Plant	9,243,520	
Pumping Machinery	52,678,290	
Subtotal, Pump Plant System		162,738,000
Subtotal, Sediment Reservoir		128,743,000
Pump Plant & Reservoir Total		291,481,000

Source: Corps, 1998.

3.4.2.4 Economic Effects: Farmland Value Approach

Introduction

In this section of the report the measurement of the economic effects to irrigators under dam breaching conditions is determined based on a change in farmland values. In order to accomplish this, typical land values for farm properties at Ice Harbor reservoir are presented. This information was compiled through discussions with farm managers, cooperative extension agents, farmland appraisers, agricultural economics professors, and the use of published enterprise budget sheets for a number of crops. An analysis of this data provides an estimate of typical farmland value and permits the quantification of the economic effect to the farmland under dam breaching conditions.

Approximately 37,000 acres of irrigated farmland currently rely on pumped water from the Snake River, specifically Ice Harbor reservoir. In addition to the estimated 28,400 acres of the more traditional irrigated cropland there are 8,600 acres of poplar plantations.

Farmland Value

Following is a summary of the estimated value of the different types of irrigated farmland in southeastern Washington State.

Row Crops

A local farm manager knowledgeable about market values indicated that supply of land on the market is currently limited and demand is high, resulting in high prices for land. He estimates that row cropland, anchored by potatoes in the crop rotation, has an approximate value of $2,500 to $3,500 per acre. This estimate is based on potatoes generating net income of $450 per acre and other crops (wheat, sweet corn, alfalfa, beans, field corn) generating net income of $225 per acre. Assuming potatoes are grown one year in four, average net income per acre is approximately $280. Land appraisal data from other sources confirms that this is a reasonable estimate of the value of row cropland. Of course there are many variables that could cause actual values to vary from this range, such as terrain, soil, and accessibility to water.

Apples, Cherries

The Farm Business Management Report for red delicious apples states that the value "varies considerably depending on the age of trees and their current and potential production levels. The better apple orchards in this area are 10 to 20 years old with an annual production level of 40 bins or more per acre. Such an orchard is currently valued at about $12,000 per acre. Eventually the value of the orchard will decrease due to age of trees and the irrigation system to about $5,000 per acre."

In the opinion of an extension economist for Washington State University, valuation of $12,000 per acre for apple orchards is probably low for the Ice Harbor farms. The Farm Business Management Report is based on Wenatchee, Washington orchards. The orchards in the Ice Harbor vicinity are probably younger and more productive than Wenatchee orchards. His estimate of value is near $15,000.

Another, higher value estimate for fruit orchards was put forth by Benton County Cooperative Extension. Value increases with tree density, quality of irrigation system, frost-control equipment, trellised orchards, and tree maturity. In general, the Ice Harbor orchards are dense with good irrigation and frost control systems, and are trellised and have mature crops. For these farms establishment costs run from $25,000 to $32,000 per acre. Initial tree costs alone, assuming 1,000 trees per acre at $7 per tree, may account for $7,000 per acre of these establishment costs. The market value should reflect these establishment costs.

Appraised value data for four orchards sold within the last two years in southeastern Washington documented that the values of these properties ranged from $9,900 to $11,900 per acre. In the opinion of a local appraiser, $10,000 per acre is a reasonable average value to use for apple orchard land.[1/]

Vineyards

Washington State University Farm Business Management Reports also provide estimates of the costs of establishing a Concord grape vineyard. For this perennial crop four years are needed to develop a mature vineyard. Total investment costs over the four year period, net of revenues, are about $7,000. Including the value of raw land, estimated at $2,500 per acre, raises the total value of a mature vineyard to $9,500. This assumes the market equilibrium price would eventually stabilize at a level to cover costs.

Local appraiser information indicates that $5,500 per acre for vineyard property is a reasonable average value estimate for the study area.

[1/] Regional land valuation experts that were contacted by the Walla Walla District economist provided appraisal data. Because this type of data for specific properties is usually confidential, the appraiser names and properties are not disclosed.

Poplars

Estimating the value of poplar/cottonwood acreage is difficult because of the lack of available historical market value data. Pacific Northwest Regional Extension Bulletin "High Yield Hybrid Poplar Plantations in the Pacific Northwest" (PNW356) is one source of value information. The net present value per acre of the crop, defined as discounted future revenues less discounted future costs, varies with assumptions about product price, age at harvest, and productivity, among others. Table 9 of the bulletin lists present values for different combinations of these factors. For example, as pulp price varies from $20 to $32 the net present value per acre with harvest at age 7 ranges from $-44 to $431. This range reflects net present value sensitivity to price. Presumably, the market value of the property would be a combination of the raw land value and the market's assessment of the net present value of the cottonwood crop at any point in the crop's cycle. In addition, the market value should include the value of the irrigation system, if any.

Information provided by local appraisers indicates that the tree farms are generally appraised similarly to row crop property. Therefore, the estimated market value of this type of farmland is $2,500 to $3,500 per acre.

Farmland Value Summary

Table 3.4-6 is a summary of the estimated market value of the primary types of irrigated farmland in the region. In addition, local farm appraisers and agricultural experts have indicated that farmland near Ice Harbor reservoir is generally not suitable for growing non-irrigated crops such as wheat because of low rainfall. Therefore, this farmland without irrigation water is limited to some grazing a short period of the year and would sell for $75 to $150 per acre.

Table 3.4-6. Farmland Value Estimates for Selected Crops

Type of Cropland	Value per Acre ($)
Row Crops	2,500 to 3,500
Vineyards (at maturity)	5,500 to 9,500
Apple Orchards (at maturity)	10,000 to 32,000
Poplars	2,500 to 3,500
Non-irrigated Farmland	75 to 150

Estimated Economic Effect Based on a Change in Land Value

Detailed crop information for about 20,000 of the irrigated acres at Ice Harbor was collected through interviews with farm operators. The crop information in conjunction with the farmland value data described above was used to determine the average per acre value of irrigated farmland in the region. Table 3.4-7 summarizes the results of the analysis of six farms that comprise over 20,000 of the irrigated acres that would be impacted under dam breaching conditions. Based on the farmland value approach, the average per acre value of irrigated farmland of $4,100. Corps of Engineers planning guidance suggests that any economic analysis of the change in land values should be based on the market value of the property.

Table 3.4-7. Estimated Market Value of Irrigated Acreage Served by Pumped Water from Ice Harbor Reservoir, Sample Farms (1998 dollars)

Farm/Crop Distribution	Acres	Per Acre Farmland Value ($)	Total Value ($)	Value/Acre by Farm ($)	Percent of Sample Acreage by Farm (%)	Average Per Acre Value of Total Farmland ($)
Farm A						
Potatoes	*	2,500	-			
Winter Wheat	*	2,500	-			
Grain Corn	*	2,500	-			
Onions	*	2,500	-			
Sweet Corn	*	2,500	-			
Total	9,500		23,750,000	2,500	47	
Farm B						
Potatoes	*	2,500	-			
Winter Wheat	*	2,500	-			
Grain Corn	*	2,500	-			
Total	2,210		5,525,000	2,500	11	
Farm C						
Red Delicious Apples	*	10,000	-			
Concord Grapes	*	5,500	-			
Total	2,700		16,650,000	6,167	13	
Farm D						
Red Delicious Apples	*	10,000	-			
Sweet Cherries	*	12,000	-			
Total	1,800		18,100,000	10,056	10	
Farm E						
Potatoes	*	2,500	-			
Winter Wheat	*	2,500	-			
Sweet Corn	*	2,500	-			
Hay	*	2,500	-			
Seed Peas	*	2,500	-			
Grain Corn	*	2,500	-			
Subtotal	2,913		7,282,500	2,500	14	
Farm F						
Red Delicious Apples	*	10,000	-			
Sweet Cherries	*	12,000	-			
Subtotal	1,030		10,560,000	10,252	5	
Average Value Per Acre, Sample Farms:						**4,100**

* Distribution of acreage by crop confidential.

The procedure used to estimate the per acre value of farmland is summarized in Table 3.4-7 and briefly discussed in this paragraph. A total farm value estimate was developed for each of the six farms by multiplying the acres of each crop grown at each farm by the low end range of the per acre crop land values presented in Table 3.4-6. The average per acre value of each farm was then determined by dividing the total farm value by the number of acres. The average per acre value of each farm was then multiplied by the percentage of the combined acreage associated with that farm and summed to give an overall average per acre value of irrigated farmland of $4,100.

By applying this average per acre value to the total amount of irrigated crop acreage, and adding the value of the poplar tree acreage, and then subtracting the value of non-irrigated cropland an estimate of the net economic impact to pump irrigators under dam breaching conditions is estimated.

Therefore: ($4,100 * 28,400 acres) + ($2,500 * 8,600 acres) - ($100 * 37,000 acres) =

$116,440,000 + $21,500,000 - $3,700,000 = $134,240,000.

The economic effect of dam breaching measured on the basis of a change in farmland value is equal to $134,240,000.

3.4.2.5 Economic Effects: Net Farm Income Analysis

Introduction

This analysis is included to verify that the previously described market value approach provides reasonable land value estimates. For the net farm income analysis typical crop budgets and the associated net returns are evaluated. The capitalized value of net farm income for the different crops in the base condition compared to the dam breaching condition provides a measure of the economic effects to irrigation water users. Including the analysis of typical crop budgets provides an indication as to whether or not the land value analysis approach presents a realistic estimate of economic effects.

Approximately 37,000 acres of irrigated farmland currently rely on pumped water from the Snake River reservoirs. In addition to the estimated 28,400 acres of the more traditional irrigated cropland there are 8,600 acres as poplar plantations.

Estimated Economic Effect Based on a Change in Net Farm Income

An analysis of typical crop budgets and agricultural statistics is summarized in this section. All data are based on Farm Business Management Reports of Washington State University (Table 3.4-8 lists the crop budgets). The typical farm values discussed in the previous section are recalculated in this section by applying net economic returns using the crop budgets. For each crop they are calculated as the difference between revenues less variable costs and net fixed costs. Net fixed costs are defined as total fixed costs less land rents and establishment charges. Typically, the establishment charge includes costs such as the purchase and planting of trees/vines with the initial development of the farm property. By excluding land rents and establishment charges from fixed costs, the net return estimate reflects a return to land and investments over time in the enterprise. It is believed this return corresponds well to the market value of the enterprise on a capitalized basis.

Net Return = Total revenues – (Total Variable Cost + Net Fixed Costs)

Where Net Fixed Cost equals Total Fixed Cost less Land Rent and Establishment Charge.

Table 3.4-8 is a summary of the crop budget data for all crops but cottonwoods. The table identifies the specific Washington State University crop budgets used in the analysis.[2/] The last column in this table provides an estimate of net returns per acre. These estimates do not, in fact, represent any one particular operation. Therefore, the farm income and value estimates must be viewed as general guidelines about typical income levels generated by the types of crops grown in Franklin and Walla Walla counties.

Applying the net returns shown in Table 3.4-8 to the crop distributions of specific farms in the Ice Harbor area provides another method of determining the average per acre value of farmland. Net returns are applied only to the acreage now served by irrigation water from the Ice Harbor reservoir. The acreage and crop distribution information was collected through interviews with the farm operators.

The crop information in conjunction with the crop budget data is used to determine the average per acre value of irrigated farmland in the region. Table 3.4-9 summarizes the results of the analysis of the six farms constituting over 20,000 of the irrigated acres that would be impacted under dam breaching conditions. Total return is the product of acreage and net return per acre. For each farm, total return per crop is summed to derive a total for all acreage irrigated from the Snake. This represents total annual net returns per farm. This annual value is capitalized in the column labeled "Present Value". A discount rate of 6.875 percent and a horizon of 20 years were assumed in calculating present value. This present or capitalized value of each farm, weighted by the number of acres provides an estimate of the market value of the land. This evaluation indicates that the average per acre value of irrigated farmland equals $4,500, a similar result compared to the land value approach.

By applying this average capitalized net return value to the irrigated crop acreage and adding the value of the poplar tree acreage, and then subtracting the value of non-irrigated cropland an estimate of the economic impact to pump irrigators under dam breaching conditions is estimated.

Therefore: ($4,500 * 28,400 acres) + ($2,500 * 8,600 acres) - ($100 * 37,000 acres) =

$127,800,000 + $21,500,000 - $3,700,000 = $145,600,000.

Water Supply

Conclusions about the Effect of Dam Breaching on Irrigated Agriculture at Ice Harbor

As noted in the introduction, the purpose of this analysis is to determine the direct economic effects to agricultural users of pumped water from the lower Snake River under dam breach conditions. As a result of unanticipated escalation in the estimated cost to modify the pump stations, the evaluation of farmland values and typical net returns using available information were introduced into the analysis. This approach was added to the analysis for comparison to the modification cost approach,

[2/] Note budgets reflecting 1997 costs and returns are now available, but were not when the analysis was initiated. A brief review of the 1997 budgets and comparison to the older versions indicates that the overall per acre net income would be slightly higher than what has been used in this analysis.

Table 3.4-8. Per Acre Revenue, Cost, and Profit Data for Irrigated Cropland Served by Ice Harbor Reservoir Water (1998 dollars)

Crop	Price ($/unit)	Quantity (unit/acre)	Total Revenue ($/acre)	Total Variable Cost ($/acre)	Total Fixed Cost ($/acre)	Land Rent ($/ac)	Amortized Establishment Charge ($/acre)	Total Fixed Cost Less Land Rent & Establishment Charge ($/acre)	Per Acre Return to Land & Establishment ($/acre)
Potato	85	28.5	2,423	1,770	654	400	-	254	399
Alfalfa	95	8	760	258	340	180	59	101	401
Winter wheat	3.5	120	420	220	169	125	-	44	156
Grain Corn	102	5	510	430	193	125	-	68	12
Silage Corn	20	30	600	532	198	125	-	73	(5)
Sweet Corn	64	9	576	376	256	180	-	76	124
Concord Grapes	7	250	1,750	979	1,454	125	915	414	357
Sweet Cherries	925	7	6,475	3,916	2,628	240	1,528	860	1,699
Red Delicious Apples	125	40	5,000	2,325	1,916	-	765	1,151	1,524
Asparagus	0.50	4,000	2,000	1,431	752	150	301	301	268
Onions	90	27	2,430	1,671	561	200		361	398
Seed Peas	15	30	450	325	220	125		95	30

Source: Selected Farm Business Management Reports Produced by Washington State University, Cooperative Extension.

EB1609, Cost of Establishing and Producing Sweet Cherries In Central Washington, Hinman et al, 1991.

EB1720, 1992 Estimated Cost of Producing Red Delicious Apples In Central Washington, Hinman et al, 1992.

EB1667, 1992 Enterprise Budgets for Alfalfa Hay, Potatoes, Winter Wheat, Grain Corn, Silage Corn, and Sweet Corn Under Center Pivot Irrigation, Hinman et al, 1992.

EB1572, Economics of Establishing and Operating a Concord Grape Vineyard, Schimmel et al, 1990.

EB1588, Establishment and Annual Production Costs for Washington Wine Grapes, Chvilicek et al, 1990.

EB1753, 1993 Estimated Cost and Returns for Producing Onions Under Rill Irrigation Columbia Basin, Washington, Hinman et al, 1993.

EB1666, 1992 Enterprise Budgets for Fall Potatoes, Winter Wheat, Dry Beans, and Seed Peas Under Rill Irrigation, Hinman et al, 1992.

EB1779, Asparagus Establishment and Production Costs in Washington, Joshua et al, 1994.

and to determine whether or not it provides an acceptable estimate of NED costs. A summary of the estimated economic effects measured by each approach is provided in Table 3.4-10. This table shows that the economic effects to pump irrigators under dam breaching condition range from $134.2 to over $300 million ($291.5 million construction plus O&M) based on the three approaches used in this analysis. The pump modification costs are significantly higher than the estimate of the change in land value, therefore, it is reasonable to conclude that this option is not economically viable, and is an overstatement of the economic effects. The land value approach is therefore carried forward as the approach to measure the economic effects to pump irrigators at Ice Harbor reservoir.

Table 3.4-9. Estimated Total Return and Market Value of Acreage Served by Pumped Water from Ice Harbor Reservoir, Sample Farms (1998 dollars)

Farm / Crop Distribution	Acres	Net Return per Acre (based on crop budgets) ($)	Total Return ($)	Present Value by Farm ($)	Value / Acre by Farm ($)	Percent of Sample Acreage by Farm (%)
Farm A						
Potatoes	*	399	-			
Winter Wheat	*	156	-			
Grain Corn	*	12	-			
Onions	*	398	-			
Sweet Corn	*	124	-			
Total	9,500		2,000,700	21,477,819	2,261	47
Farm B						
Potatoes	*	399	-			
Winter Wheat	*	156	-			
Grain Corn	*	12	-			
Total	2,210		274,040	2,931,604	1,327	11
Farm C						
Red Delicious Apples	*	1,524	-			
Concord Grapes	*	357	-			
Total	2,700		1,430,000	15,305,233	5,669	13
Farm D						
Red Delicious Apples	*	1,524	-			
Sweet Cherries	*	1,699	-			
Total	1,800		2,751,950	29,439,599	16,355	10
Farm E						
Potatoes	*	399	-			
Winter Wheat	*	156	-			
Sweet Corn	*	124	-			
Hay	*	12	-			
Seed Peas	*	30	-			
Grain Corn	*	12	-			
Subtotal	2,913		588,681	6,297,541	2,162	14
Farm F						
Red Delicious Apples	*	1,524	-			
Sweet Cherries	*	1,699	-			
Subtotal	1,030		1,592,470	17,035,803	16,540	5
Avg. Value Per Ac., Sample Farms:						4,500

* Distribution of acreage by crop confidential.

Table 3.4-10 summarizes the present value estimates for the pump modification approach, the irrigated farmland value approach, and the net farm income approach. Included are the average annual costs using different discount rates. It has been determined that the most reasonable (least cost) estimate of the NED costs is provided by the approach that estimates the change in farmland value based on assessed values under dam breaching conditions.

Table 3.4-10. Comparison of the Approaches to Measure Direct Economic Effects to Pump Irrigators, Under Dam Breach Conditions (1998 dollars)

Approaches to Measure Direct Economic Effects	Direct Economic Effect ($)	Average Annual Cost (6.875% Discount Rate) ($)	Average Annual Cost (4.75% Discount Rate) ($)	Average Annual Cost (0.0% Discount Rate) ($)
Pump Modification Cost Approach				
--Construction:	291,481,000	20,065,550	13,979,400	2,914,800
--O&M:		3,573,000	3,573,000	3,573,000
Total Annual Modification Cost		23,638,550	17,552,400	6,487,800
Loss of Irrigated Farmland Value:	-	-	-	-
(1) Assessed Value Approach	134,240,000	9,241,100	6,438,100	1,342,400
(2) Net Farm Income Approach	145,600,000	10,023,100	6,983,000	1,456,000

3.4.3 Other Water Users

3.4.3.1 Introduction

In this chapter, potential economic effects to other water user groups under dam breaching conditions are described and analyzed.

Specifically, the economic effects to municipal and industrial (M&I) water users and private well users in close proximity to the reservoirs are measured. For these other water categories, the measurement of economic effects are based on the required system modification costs. These modification costs serve as a proxy measurement of the true NED costs.

This report is intended to provide only a brief summary of the modification costs. Additional details about the specific modifications required are provided in the Engineering Appendices (Technical Appendices D and E).

3.4.3.2 Municipal and Industrial Pump Stations

There are several M&I pump stations all located on the Lower Granite pool. Uses range from municipal water system backup, golf course irrigation, industrial process water for paper production, and concrete aggregate washing.

Table 3.4-11 lists these facilities. The largest station is owned and operated by the Potlatch Corporation. Two of the stations of Public Utility District (PUD) #1 in Clarkston have not been operated in the past few years and there are no plans to use them in the immediate future. The District is considering moving one plant to a new location. One of the stations is a shared station between Atlas Sand and Rock and Lewiston Golf Club. Atlas uses water pumped from a 100 HP plant for washing aggregate and the golf club uses the smaller 60 HP pump to irrigate the course. The remaining plants are small with limited horsepower. These smaller plants are used to irrigate golf courses and parks. Data for these plants are summarized in Table 3.4-11. Sources for this information include managers of the stations, Walla Walla District engineers, and previous consultant documentation (Anderson-Perry, 1991).

Table 3.4-11. Municipal & Industrial Pump Stations on Lower Granite Reservoir

Ref. No.	Station	River Mile	Use	Number of Pumps	Horsepower	Head (ft)	1996 Water Usage
GR-1	PUD #1	143	Water System Backup	3	450	300	Not used in several years
GR-2	PUD #1	143	Water System Backup	3	1,200	400	Not used in several years
GR-3	Clarkston Golf Course	137	Golf Course Irrigation (90 acres)	1	10	40	460,000 gal/day
GR-4	Potlatch Corp. (Clearwater R)	CW 4	Mill process water and steam generation	6	1,050	80	12,287,000,000 gal
GR-11a	Atlas Sand & Rock	142	Concrete aggregate washing	1	100	120	Na
GR-11b	Lewiston Golf Club	142	Golf Course Irrigation	1	60	160	1.0-1.5 mgd in June to Aug.

Sources: Survey of Station Managers; Walla Walla District Engineers 1997/1998; Anderson-Perry, 1991.

Following is a summary of potential pump modifications.

- The two PUD stations have not been used in several years and will not be modified.
- The Clarkston Golf Course potential modifications include construction of a utility building, water intake system, and power supply.
- The Potlatch Corporation station modifications are extensive and include the primary plant intake and the plant diffuser, and potentially a water cooling facility.[3/]
- The Atlas Sand and Rock facility potential modifications include construction of a utility building, water intake system, power supply.
- The Lewiston Golf Course potential modifications include construction of a utility building, water intake system, power supply.

[3/] Final determination about the extent of required system modifications has not been made.

The total estimated modification costs for these municipal and industrial pump stations on Lower Granite reservoir (excluding the park stations) are $11,514,000 to $55,214,000. There is a cost range because the required modification costs for Potlatch Corporation depends on whether or not a discharge water cooling facility will be necessary. The Potlatch Corporation system modifications are either $10.8 million or $54.5 million of the total.

Increased energy costs for the modified M&I pump stations have not been quantified. Of the subset of M&I pump stations the largest pumps are owned by PUD #1 and the Potlatch Corporation which account for over 90 percent of total M&I horsepower. The PUD pumps, which are backup water supply pumps, have not been used in several years and there are no immediate plans for their use. Therefore, quantifying increased energy costs for the systems would be very speculative. The Potlatch pump does not face increased head and consequently energy costs would not be greater under dam breaching conditions compared to current conditions. The remainder of M&I pumps would experience increased pumping costs but the magnitude of those increased costs would be negligible compared to energy costs for agricultural stations.

3.4.3.3 Privately Owned Wells

The number of water wells within approximately one-mile of the Snake River was compiled from well water reports. The well logs were obtained by searching and copying records of the Washington Department of Ecology. Wells within the one-mile distance were included as the range encompassing wells that might be affected under dam breaching conditions. The topographic features of the area, stratigraphy, and surface elevation directly influence which wells would be affected by the change in river water surface elevation.

A total of 228 well reports were counted. Review of the well reports showed that 9 reports were for test wells, 1 for an abandoned well, 2 for replacement wells, and 7 reports for wells that were deepened but not matched with original well reports. Adjusting the number of reports for test wells, abandoned wells, replacement wells, and possible duplication for deepened wells indicates the actual number of functioning wells may be as low as 209.

Some of the reports provided information about what the wells are used for and where they are located. Table 3.4-12 provides a breakdown of the well reports by county and use. In terms of number of well reports, domestic use appears to be the dominant use, followed by irrigation. About 11 percent of the reports had more than one use checked off. In almost all cases where more than one use was indicated, both irrigation and domestic use were indicated. Many of the older reports did not include any usage information.

Only 55 of the well reports indicated the horsepower of the pump. Many of the pumps were smaller sized although horsepower did range up to as large as 700 HP. Average horsepower was 70 and the median horsepower was 10. The average depth of the wells was about 270 feet. Table 3.4-13 summarizes information about the distribution of well pump capacities.

Examination of the individual reports indicates the larger pumps appear to be associated with irrigation usage. From previous information [Anderson-Perry, 1991] and recent phone conversations with farm operators, it is known that some of the agriculture operations have significant irrigation capability from wells. For example, one operation has four well pumps with 1,300 total horsepower irrigating 1,200 acres of potatoes, wheat, sweet corn and onions, while

Table 3.4-12. Number of Well Reports Disaggregated by Use and County

Use	Asotin	Columbia	Franklin	Garfield	Walla Walla	Whitman	Total	Percent of Total (%)
Domestic	40	2	9	3	12	12	78	35
Industrial				1	2	3	6	3
Irrigation	7	1	18	1	9	4	40	18
Multiple	5	5	4	4	3	4	25	11
Municipal	7				2	1	10	4
Other	2		9	2	2	1	16	7
Test Well	3		4			2	9	4
Not Reported	3	4	5	2	15	12	41	18
Total	67	12	49	13	45	39	225	
Percent of Total (%)	30	5	22	6	20	17	100	

Note: County data could not be read on 3 well reports. Uses for these three included 1 test well and 2 not reported.
Source: Well record data, Washington State Department of Ecology.

Table 3.4-13. Distribution of Pump Horsepower for Wells

Horsepower	Number of Pumps
< 2	17
2 – 10	11
10 – 100	17
> 100	10

Source: Well record data, Washington State Department of Ecology.

another operation has two wells with 240 horsepower irrigating 170 acres of vineyards and orchards. An orchards indicated it has two 700-horsepower and five 500-horsepower well pumps (in addition to its eight river station pumps) for irrigation of orchards. It is likely that other agricultural operations also irrigate from wells, but identification of all irrigation well stations was beyond the scope of this analysis.

The Corps analyzed a representative sample of the existing wells to determine potential modifications to the wells and cost. Fifty wells were selected and analyzed. Well log data coupled with topographic features of the area provided information on well depth, stratigraphy, surface elevation, and ultimately which wells would be affected by the change in river water surface elevation. Results of the analysis showed that 21 of the 50 sampled wells would be impacted under dam breaching conditions. Refer to the engineering appendices for a description of each of the 50 sampled wells and modification cost estimate details (Technical Appendices D and E).

For these 21 affected wells in the sample the amount of additional drilling and head that would be required for effective operation at natural river levels was determined. With this information the Corps calculated the necessary modifications, particularly in pump size and increases in well depth that would be required to maintain a constant water supply. The modification cost for the average well was also calculated.

The average cost per well was applied to the entire number of wells anticipated to be affected, as determined from percentages calculated in the representative sample. About 40 percent or 95 wells are expected to need modifications. Table 3.4-14 presents the total well modification cost by reservoir. Total costs are equal to $56,447,000, which includes direct, contingency, project management, and overhead costs.

Table 3.4-14. Well Modification Cost Estimates by Pool (1998 dollars)

Pool	Well Modification Cost ($)
Ice Harbor	18,373,000
Lower Monumental	12,462,000
Little Goose	7,797,000
Lower Granite	17,815,000
Total	56,447,000

Source: Corps, 1998.

The cost estimate was based on a typical cost per well with average increases in pump size and well depth. As a practical matter, each well would have to be considered individually under dam breaching conditions. Only by observing conditions after dam breaching has occurred can one determine exactly how deep a well would have to be drilled to produce water at current rates. It is recommended that all well modifications be performed after dam breaching has occurred. It is unclear what the water well users would do in the interim. An estimate for additional O&M expenses associated with the well modifications has not been determined.

3.4.3.4 Conclusions about the Effect of Dam Breaching on Other Water Users

Table 3.4-15 summarizes the cost of the water supply modifications that are required under dam breaching conditions. These modifications will allow the water users to continue to operate as they currently do. Estimated water supply economic losses are based on the costs of modifying pump stations and wells. Therefore, the water supply economic effects to M&I and private well users are equal to the total modification costs. Average annual costs are calculated using three different discount rates for the 100-year evaluation period.

Table 3.4-15. Summary of Other Water Supply Modification Cost Estimate, M&I and Private Wells (1998 dollars)

Water Supply Category	Construction Cost ($)	Average Annual Cost (6.875% Discount Rate) ($)	Average Annual Cost (4.75% Discount Rate) ($)	Average Annual Cost (0.0% Discount Rate) ($)
Municipal and Industrial Pump Stations	11,514,000 to 55,214,000	792,600 to 3,800,900	552,200 to 2,648,100	115,000 to 552,000
Privately Owned Wells	56,447,000	3,885,800	2,707,200	564,500
Total	67,961,000 to 111,661,000	4,678,400 to 7,686,700	3,259,400 to 5,355,300	679,500 to 1,116,500

Source: Corps, 1998. M&I cost range is due to the current uncertainty about the required modifications to the Potlatch Corporation system.

3.4.4 Summary of Economic Effects to Water Users

Table 3.4-16 summarizes results of the analysis of effects to water users under dam breaching conditions. Three water user categories were evaluated in this report—loss of irrigated farmland value, municipal and industrial pump station modifications, and private well modifications. Results of the analysis of the economic effects are presented using three different discount rates.

The total economic effect associated with the three categories ranges between $202,201,000 to $245,901,000 (in present value terms). This range reflects uncertainty surrounding system modifications that might be required at the Potlatch facilities in Lewiston, Idaho. The loss in irrigated farmland value represents over 50 percent of the total water supply economic effects. It is anticipated that economic effects summarized in Table 3.4-16 would be incurred the year that dam breaching occurred. Therefore, the economic effects do not need to be adjusted to the base year 2005.

Table 3.4-16. Summary of Economic Effects to Water Users (1998 dollars)

Water Supply Category	Economic Effect ($)	Average Annual Cost (6.875% Discount Rate) ($)	Average Annual Cost (4.75% Discount Rate) ($)	Average Annual Cost (0.0% Discount Rate) ($)
Loss of Irrigated Farmland Value	134,240,000	9,241,100	6,438,100	1,342,400
Municipal and Industrial Pump Stations	11,514,000 to 55,214,000	792,600 to 3,800,900	552,200 to 2,648,100	115,000 to 552,000
Privately Owned Wells	56,447,000	3,885,800	2,707,200	564,500
Total	202,201,000 to 245,901,000	13,919,500 to 16,927,800	9,697,500 to 11,793,400	2,021,900 to 2,458,900

Source: Corps, 1998.

3.4.5 Sensitivity Analysis of the Economic Effects to Irrigated Agriculture

A sensitivity analysis of key variables of the irrigated agriculture study is summarized in this section. The results of this sensitivity analysis do not change the estimated economic effects already described, but rather provide an indication of how the estimates would change given different assumptions. The results of the irrigated agriculture analysis present the most likely economic effect of dam breaching, given the available data and necessary assumptions. The intent of this sensitivity analysis is to provide some perspective about the uncertainty in our estimates and demonstrate how the application of different assumptions could change the results.

The sensitivity analysis is focused on two key components of the irrigated agriculture study: (1) the actual number of irrigated acres that would be taken out of production; and (2) the impact of varying the net income estimates. Three separate sensitivity scenarios are presented.

3.4.5.1 Sensitivity Analysis Scenarios

Scenario 1: Orchard and Vineyard Acreage Remains in Production Under Dam Breaching Conditions

The irrigated agriculture analysis concluded that the most likely consequence of dam breaching would be the removal of about 37,000 acres access to irrigation water. This was concluded because no technically and economically viable modified irrigation delivery system was identified under dam breaching conditions. Early on in this study it was determined that not all system modification possibilities, including farm level modifications would be analyzed. And since all combinations were not evaluated it is possible, although speculative, that some of the farm operators would find a way to continue to provide irrigation water to a portion of the farmland, under dam breaching conditions. For this scenario it is assumed that all fruit orchards and vineyards could be kept in production under dam breaching conditions. A summary of the change in economic effects under this scenario follows.

Of the 37,000 acres that are likely to be impacted by dam breaching, approximately 7,750 acres or 21 percent are vineyards and fruit orchards. This 21 percent represents about 51 percent of the estimated value of the 37,000 acres of irrigated land. Consequently, if we assume in this sensitivity analysis that these permanent croplands could be kept in production the overall economic effect on the region would be reduced by about half. Under the assumption that all 37,000 acres go out of production the estimated value of the property is reduced about $134,240,000. Whereas, keeping the permanent crops in production reduces the impact to a little more than $64,170,000.

As noted earlier, the intent of presenting these numbers is to show the sensitivity of the estimated economic effect to a reduction in the number of acres that are impacted. Again, no specific irrigation system was identified to permit this acreage to remain in production. In addition, on-farm or other irrigation system modification costs that would be required to allow irrigation to continue is not included, so the $64,170,000 estimate is unrealistically low. However, it is reasonable to conclude that under these assumptions the economic effects would be no less than $64,170,000.

Scenario 2: Additional Irrigated Acreage Impacted Under Dam Breaching Conditions

This irrigated agriculture report has concluded that the most likely consequence of dam breaching would be the removal of access to irrigation water for about 37,000 acres. The estimated number of acres impacted under dam breaching conditions was determined through interviews with current farm operators. It is believed that the information compiled from the interviews provides a census of pump irrigated acreage that would be impacted under dam breaching conditions. However, during the development of this document some individuals indicated that they felt the actual number of acres that would be impacted is significantly higher. For instance, the Natural Resources Conservation Service (NRCS) indicated there are over 50,000 acres of irrigated farmland adjacent to Ice Harbor. In this analysis it was assumed that the majority of this additional acreage is irrigated with well water, and therefore the economic impacts under dam breaching conditions are captured in the well modification cost estimate. However, if this assumption is incorrect then it is possible, although speculative, that the economic effect under dam breaching conditions is significantly higher. Following is a summary of the change in economic effects under this scenario.

Assuming the additional 13,000 acres are the same mix of crops as the 37,000 acres that were previously evaluated, the economic effects are 35 percent higher. Under the assumption that 37,000 acres go out of production the estimated value of the property is reduced about $134,240,000. Whereas, if we assume that 50,000 acres are impacted then the total economic effect increases to $181,224,000.

The intent of presenting these numbers is to show the sensitivity of the estimated economic effect to an increase in the number of acres that are impacted. Although there has been some speculation that the number of acres that would be impacted as a result of dam breaching may be greater than 37,000, no specific documentation could be identified.

Scenario 3: Net Return Estimates Decreased by as Much as 25 Percent

A major conclusion of the irrigated agriculture report is that breaching of the dams will eliminate access to irrigation water for about 37,000 acres of farmland. In determining the economic effect associated with the removal of irrigation water, an analysis of generic crop budgets for the primary crops was completed and an estimate of the value of impacted farmland was developed. Applying generic budgets to these 37,000 acres required significant generalization of many factors. Variables such as regional differences in irrigation pumping costs, adjustments for salvage values, and real estate taxes were not adjusted/incorporated in the crop budget analysis. In addition, uncertainty about what the political and economic future may hold for agriculture in terms of crop subsidies, impacts to capitalized land values due to changing risk factors, and crop prices received by farmers was not addressed.

As a result of the use of generalized crop budgets in this analysis, the true net return values for the major crops near the Ice Harbor reservoir may actually be lower than the values calculated and used to estimate farmland values. To test the influence of the applied net returns on the estimate of economic impacts, the net returns for all crops are reduced by 25 percent. Following is a summary of the change in economic effects under this scenario.

It was determined in the irrigated agriculture report the weighted value of farmland, based on net returns generated from generic crop budgets, is $4,100 per acre. Assuming that the net returns are actually 25 percent lower than the estimate used in the irrigated agriculture report the weighted value of farmland is $3,075 per acre. The estimated market value of poplar/cottonwood acreage is $1,875 per acre under this assumption. Applying the revised average per acre value to the total amount of irrigated crop acreage, adding the revised value of the poplar tree acreage, and then subtracting the value of non-irrigated cropland results in the following estimate:

($3,075*28,400)+($1,875*8,600)-($100*37,000) = $87,330,000 + $16,125,000 -

$3,700,000 = $99,755,000.

As noted earlier, the intent of presenting these numbers is to show the sensitivity of the estimated economic effect to a change in farmland value estimates. Based on the results of this sensitivity analysis it is reasonable to conclude that the actual economic effect on irrigators is likely between $99,755,000 and $134,240,000.

Conclusions of Sensitivity Analysis

The different sensitivity analysis scenarios are not directly combinable. However, the ranges of economic effects presented under the different scenarios do show how key variables influence the results.

The results presented in the preceding sections of this analysis reflect our best estimate of what is the most likely economic effect of dam breaching, given the available data and necessary assumptions. This sensitivity analysis provides some perspective about the uncertainty in our estimate and demonstrates how the application of different assumptions in this analysis could change the results.

3.4.5.2 Unresolved Issues

Although it is generally agreed that the water supply effects of breaching are not large when compared to the effects on hydropower, navigation, and recreation, reviewers and contributors to this document have identified issues which have not been resolved. Following is a list of the unresolved issues associated with the water supply analysis.

Irrigated Agriculture Effects

- Acceptance of the estimated land value for irrigated and non-irrigated acreage used to measure NED effects. Limited land value appraisal data were available. Therefore, generalized crop budgets were analyzed to verify the conclusions reached with appraisal/local expert opinion information. Questions as to whether the use of the generalized budgets truly corroborate the land value estimates continue. In addition the inclusion of a sensitivity analysis for this same issue does not fully address the issue. Further verification of land values would require supplementing existing appraisal data.
- Agreement as to whether or not it would be possible to keep some of the irrigated acres in production under dam breaching conditions.
- Acceptance of the modified irrigation system engineering cost estimates.

Effects to Municipal and Industrial Water Users and Privately Owned Wells

- Acceptance of the modified M&I water system engineering cost estimates.
- Acceptance of the procedures used to measure the number of wells that would be affected by dam breaching and the engineering cost estimates.

3.5 Anadromous Fish

The section summarizes the findings of the Anadromous Fish Economic Analysis prepared by the DREW Anadromous Fish Workgroup (1999). The purpose of this analysis is to identify the net economic value associated with changes in commercial and recreational anadromous fish harvest.

Projected changes in fish harvest are based on preliminary data developed through the committee-based process Plan for Analyzing and Testing Hypotheses (PATH). PATH provided data for seven index stocks for Snake River spring/summer chinook, a comprehensive review of Snake River fall chinook, and a narrative description evaluating the correlation between Snake River spring/summer chinook and steelhead. In order to analyze the economic effects of future harvests under the different alternatives, the DREW Anadromous Fish Workgroup expanded the PATH results to represent all Snake River wild and hatchery stocks. This economic analysis considered commercial and recreational harvesting of wild and hatchery fish and also sales of hatchery returns for egg, carcass, and food fish sales. Commercial and recreational harvests were allocated to user groups and geographic areas based on existing U.S. and Indian tribal agreements. Fish available after these obligations are met were distributed based on historical harvest distributions. Commercial economic values are based on ex-vessel values, while the recreational fishery value is based on a value per angler day.

The following discussion is divided into six sections. The first section provides a general overview of the changing patterns of anadromous fish production in the Columbia River Basin and briefly discusses West Coast salmon management. This section establishes the context for the economic analysis. Broadly speaking, the anadromous fish economic analysis consisted of three main components: developing estimates of fish returns under each alternative, allocating these fish by fishery and geographic area, and evaluating the NED contribution of subsequent harvests. These three parts of this analysis are discussed in Sections 3.5.2 through 3.5.4, respectively. Section 3.5.5 addresses risk and uncertainty issues associated with this analysis. The final section outlines a number of issues that were unresolved when this analysis was completed.

3.5.1 Overview

3.5.1.1 Changing Patterns of Anadromous Fish Production

To the Indians living along the Columbia River, salmon were their lifeblood, essential to their subsistence, their culture, and their religion. Salmon also played a key economic development role for European settlers. As early as 1828, various trading companies were purchasing and exporting salmon caught by Indians on the Columbia River. The first commercial use of fishery products in Oregon was salmon packing. Demand for salmon grew following development of the canning process in the mid-1800s. Total harvested pounds of salmon and steelhead in the early 1890s are estimated to have ranged from 21 to 33 million pounds.

The history of Columbia River salmon harvest has been one of transition from spears and dip nets, to seine and gillnets, to diesel engines and ocean trolling poles. As salmon became scarcer, gas-powered engines allowed fishermen to venture further out into the ocean. As ocean fisheries developed, most of the fish produced in the Columbia River Basin were harvested in marine waters from California to Alaska. The long-term effects of economic development, hatchery production, and mixed-stock, open-access fisheries have been to reduce the total, and change the species and stock composition, of salmon returning to the Columbia River. Total poundage harvested commercially in the Columbia River Basin has declined from about 9,090,909.1 kg (20 million) in the 1940s to a recent low of just over 454,545.5 kg (1 million pounds) in 1993 (Radtke and Davis, 1994). As fish numbers and commercial harvests have declined, so have the revenues to fishermen. As water-based economic development took place in the Pacific Northwest, natural-based production was supplemented by artificial propagation.

3.5.1.2 Salmon Management on the U.S. West Coast

Understandings and Agreements

A host of salmon treaties and agreements affect salmon of the Columbia River system. These can be categorized as international understandings, such as the 1992 International North Pacific Fisheries Commission Convention (Shepard and Argue, 1998); the United Nations Convention on the Law of the Sea, which entered into force in November 1994; the Pacific Salmon Treaty (PST) between the United States and Canada; harvest management agreement processes such as the Pacific Fishery Management Council (PFMC); agreements to rebuild the stocks such as the Northwest Power Planning Act; obligations to northwest Indian tribes; and, most recently, Federal mandates to protect salmon stocks under the Endangered Species Unit (ESA). Assumptions about salmon production, allocation agreements, and protection of natural runs used for this analysis took these international understandings into consideration. The PST was being renegotiated at the time of this analysis, so applicable provisions of the new agreement were not included in modeling assumptions.

3.5.2 Anadromous Fish Harvest Forecast Methods

The low rate of returning wild spawners in recent years has raised concerns about the eventual extinction of wild anadromous fish stocks in the Snake River system. During the early 1990s, for example, every two wild spring chinook spawners from the Snake River system returned about 1.2 spawners (Smith, 1998). Factors may include harvesting methods, habitat alterations, hatchery production, hydrosystem operations, and ocean conditions. The economic analysis presented here only addresses the causation factors considered in the PATH process. Readers are directed to the many PATH publications for more information concerning forecasts of harvests and returning spawners for each alternative. The National Marine Fisheries Service (NMFS, 1999) provides a biological evaluation of PATH results to estimate the recovery probabilities of ESA-listed stocks.

Information contained in the PATH results is limited to seven index stocks for Snake River spring/summer chinook, a comprehensive review of Snake River fall chinook, and a narrative description about how smolt-to-adult survival rates (SAR) between Snake River spring/summer chinook and steelhead are correlated. For spring/summer chinook and fall chinook, the information includes numbers of fish harvested in the ocean, river mainstem, and tributaries; harvest rates for ocean and mainstem based on ocean escapement (estimated adult fish counts at the entrance of the Columbia River to the Pacific Ocean); harvest rates for tributaries based on Lower Granite Dam escapement (estimated adult fish counts passing over Lower Granite Dam); and numbers of spawners. Results are reported in 5-year increments starting with Year 5, i.e., 5 years after an alternative is implemented. The PATH analyses directly incorporated potential effects of key uncertainties. Each action was analyzed across a range of assumptions reflecting alternative biological considerations, survival responses, and variations in future climate effects. As a result, the projected effects of any given action on Snake River salmon runs generated by the PATH analyses were not simple point estimates. Summary statistics were used to compile possible combinations of key assumptions across the large number of model runs. In addition to expressing projections in terms of numbers of fish, PATH also summarized results in the context of the relative probability of exceeding survival and recovery criteria. Projected numbers of fish and harvest were summarized in terms of a standard set of fractions or percentiles of the total number of combinations run for each action (10th, 25th, 50th, 75th and 90th percentiles). If the harvest reported at the 25th percentile was 100 fish, for example, that meant that 25% of the model runs for that particular action resulted in a harvest of 100 fish or less. If, for that same action, the harvest reported at the 75th percentile was 500, that meant that 75% of the runs for that action resulted in a projected harvest of 500 or less.

In order to analyze the economic effects of future harvests under the different alternatives, the DREW Anadromous Fish Workgroup expanded the PATH results to represent all Snake River wild and hatchery stocks. This required that study assumptions be made for certain additional life-cycle modeling factors beyond those included in the PATH process. A generalized life-cycle representation for Snake River salmonids is presented as Figure 3.5-1.

The assumptions used to expand PATH results should not be considered an attempt to develop a separate life-cycle model. Wherever possible, PATH modeling factors were reused as proportions in the expansion methods. The assumptions for the life-cycle modeling factors are shown by species in Table 3.5-1.

3.5.2.1 Smolt-to Adult Return Rates

Salmon and steelhead typically reproduce in fresh water and spend a greater part of their adult life in the ocean. In their migratory route, they are exposed to a variety of predators. Survival rates from production to harvest are important components of how many adult fish will be available for harvest. PATH forecasts were presented in 5-year increments, starting with Year 5 and ending with Year 100 and did not include SARs.

In order to extend the PATH information to all Snake River stocks, it was necessary to identify the Year zero run size information and identify the SARs for the modeled runs. This was necessary to identify the changes PATH projected between Years zero and 5. These ratios of change could then be applied to the other wild and hatchery stocks. Based on information from Beamesderfer et al. (1997) and the Technical Advisory Committee (TAC), the seven spring/summer chinook index stocks modeled by PATH accounted for 52 percent of all wild stocks from 1986 to 1995. The 10-year averages from 1986 to 1995 were adopted to provide the missing Year zero information for run size, SARs, and harvest rates.

Historical information was available on the survival of hatchery-reared salmon and steelhead releases and some test wild-reared anadromous fish. A survival rate was defined for the purposes of this analysis as total hatchery releases divided by the number of adults that subsequently appear in fisheries or in hatchery returns. Recent hatchery practices have mainly released fish at smolt age. Therefore, survival rates are identified as smolt-to-adult survival rates or SARs in this analysis. The 10-year average SARs (1986 to 1995) for hatchery stocks were 0.25 percent for spring/summer chinook, 0.6 percent for fall chinook, and 0.8 percent for summer steelhead. Survival rates for wild-origin fish can be calculated in a similar manner as total downstream migrating smolts divided by the number of fish harvested plus spawner escapement totals. The SAR rates used for this economic analysis differ somewhat from rates used in the

Table 3.5-1. Additional Biological Assumptions Needed to Expand PATH Results for Use in the Anadromous Fish Economic Analysis

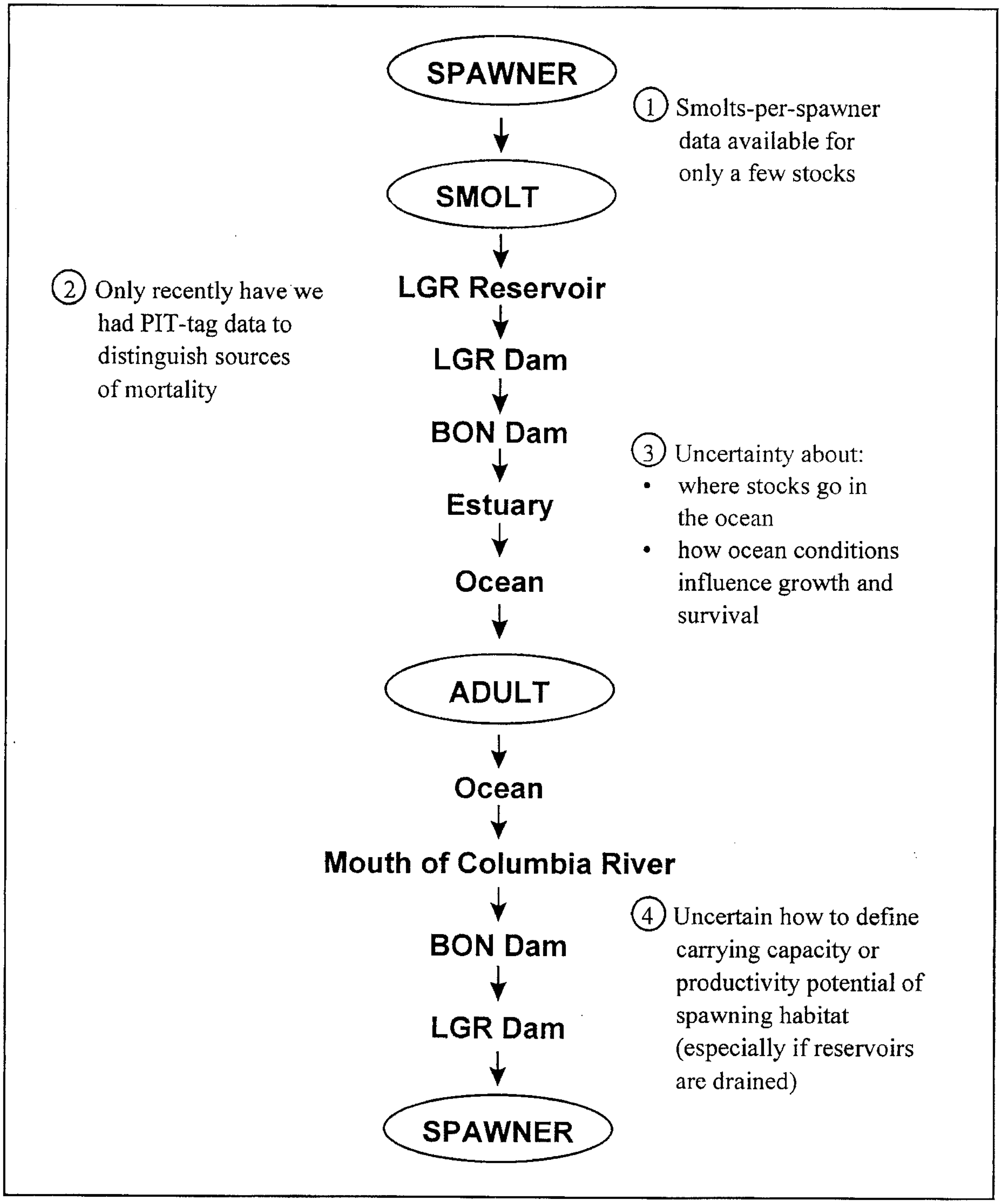
Life-Cycle/Modeling Factors	Spring/Summer Chinook	Fall Chinook	Summer Steelhead
Smolt downstream passage mortality	Nan	Nan	Nan
Ocean incidental mortality	Nan	Nan	Nan
Ocean harvest	Nan	PATH results	Nan
Run size total—wild	For Year 0, 1986-95 average from Table 2, Tab 1 and 2, TAC (1997). Future years calculated at the same percentage change as PATH results for index stock's ocean escapement. PATH results ocean escapement calculated using mainstem harvest divided by mainstem harvest rates.	For Year 0, 1986-95 average from Table 9, Tab 3, TAC (1997).	For Year 0, 1986-95 average (length method) for A and B runs Tables 12 and 13, Tab 8, TAC (1997). Future years, 37% s/s chinook SAR changes.
Run size total—hatchery	Nan	Nan	Nan
Total adults—wild	Mainstem harvest + tributary harvest + pre-spawning mortality after LWG + spawners	Total harvest + spawners + hatchery supplements. Pre-spawning mortality assumed to be zero.	Mainstem harvest + tributary harvest + pre-spawning mortality after LWG + spawners
Total adults—hatchery	For Year 0, hatchery smolt production goals in 1998 from Smith (1998) times SAR recent year averages in various CWT Missing Production Group Annual Reports (Fuss et al. 1994 and Garrison et al. 1995). For future years, hatchery production held constant and hatchery SAR same changes as wild SAR.	For Year 0, hatchery smolt production goals in 1998 from Smith (1998) times SAR recent year averages in various CWT Missing Production Group Annual Reports (Fuss et al. 1994 and Garrison et al. 1995). For future years, hatchery production held constant and SAR same changes as wild SAR.	For Year 0, hatchery smolt production goals in 1998 from Smith (1998) times SAR recent year averages in various CWT Missing Production Group Annual Reports (Fuss et al. 1994 and Garrison et al. 1995). For future years, hatchery production held constant and SAR same changes as 37% wild spring/summer chinook SAR.
Mainstem harvest—wild	For Year 0, same proportion as PATH results index stocks. For future years, PATH results expanded to represent total production.	For Year 0, Table 9, Tab 3, TAC (1997). For future years, PATH results.	Table 12 and 13, Tab 8, TAC (1997).

Table 3.5-1. Additional Biological Assumptions Needed to Expand PATH Results for Use in the Anadromous Fish Economic Analysis Continued

Life-Cycle/Modeling Factors	Spring/Summer Chinook	Fall Chinook	Summer Steelhead
Mainstem harvest—hatchery	Proportion of PATH results for mainstem harvest to total wild adults.	Proportion of PATH results for mainstem harvest to total wild adults.	Table 12 and 13, Tab 8, TAC (1997).
Tributary harvest—wild	PATH results expanded to represent total production.	PATH results	Table A1d, Tab 8, TAC (1997).
Tributary harvest—hatchery	Proportion of PATH results for index stock's tributary harvest to total wild adults	Nan	Table A1d, Tab 8, TAC (1997).
Upstream passage mortality	Nan	Nan	Nan
LWG Dam escapement—wild	(tributary harvest + spawners) ÷ 0.9. The 10% LWG prespawning mortality factor is from Marmorek (personal communication 1999).	Tributary harvest + spawners + supplements, i.e., zero assumed pre-spawning mortality.	For Year 0, 1986-95 average (length method) for A and B runs, Table 12, Tab 8, TAC (1997). Future years calculated as same percentage change as PATH results calculated LWG escapement
LWG Dam escapement—hatchery	Nan	Nan	Nan
Pre-spawning mortality—wild	10% of LWG escapement	Zero assumed pre-spawning mortality.	10% of LWG escapement
Female fraction fecundity—wild and hatchery	Female fraction 50% and fecundity 3,500	Female fraction 50% and fecundity 3,500	Female fraction 50% and fecundity 2,500
Smolt capacity and egg survival rates—wild	Smolt carrying capacity and density dependent egg-smolt survival rate	Smolt carrying capacity and density dependent egg-smolt survival rate varying from 15% in Year 5 to 2% in Year 25+	Varying from 15% in Year 5 to 2% in Year 25+
Smolt capacity and egg survival rates—hatchery	67% fecundity	67% fecundity	67% fecundity

1/ Nan—No assumption needed; SAR—smolt-to-adult survival rate; CWT—coded wire tag; LWG Dam—Lower Granite Dam.

2/ Fecundity is the number of fertilized eggs that can be attributed to a spawning pair.



Note: Annotations show examples of points in the life cycle where empirical data are missing or incomplete.
Source: NMFS (1999).

Figure 3.5-1. Straight-line Representation of a Generalized Life-cycle for Snake River Salmonids simulation modeling conducted by PATH. The definition change was needed to align expressions of wild adult returns with those reported in other publications for hatchery adult returns.

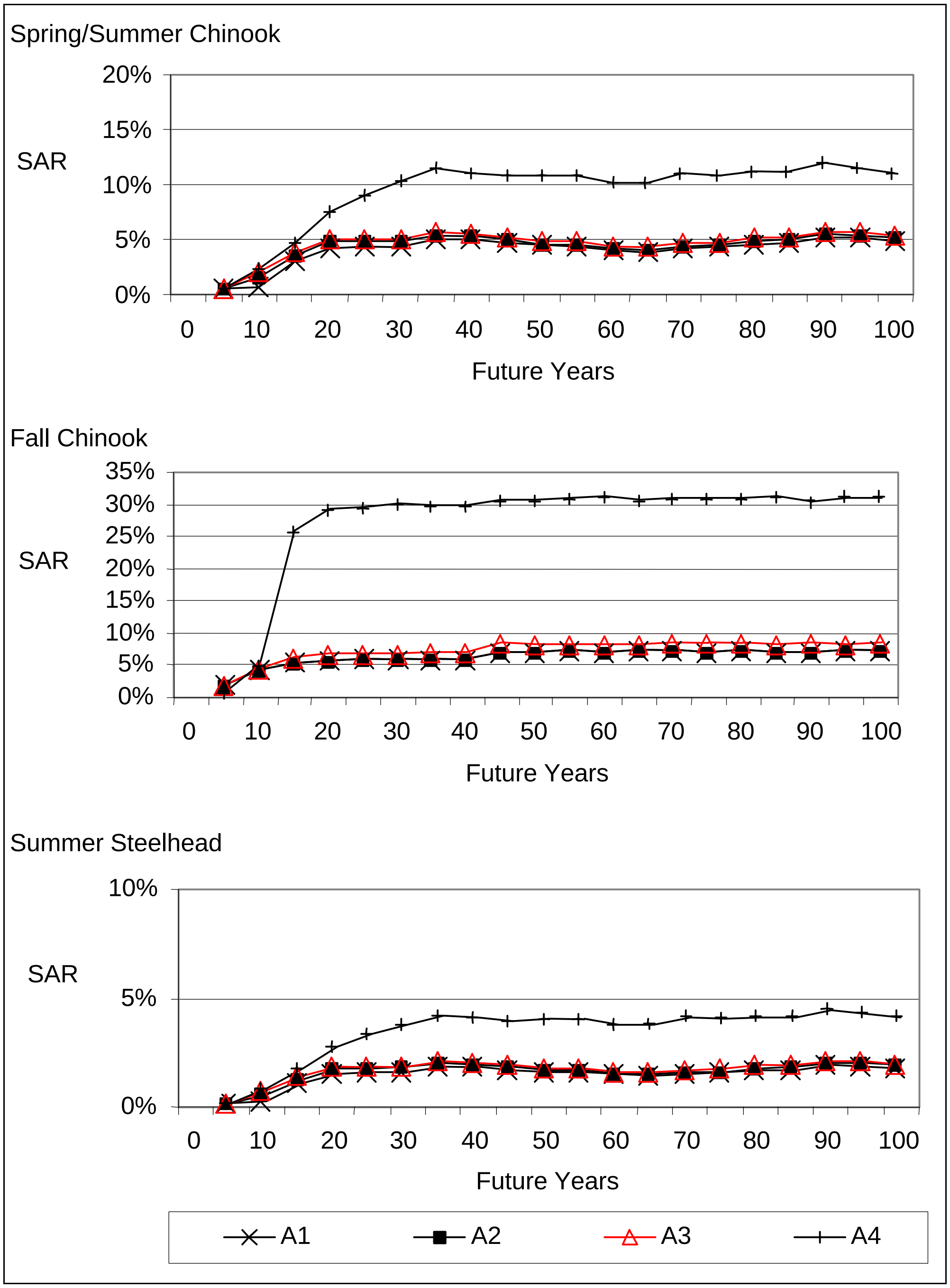
Indicator SAR rates were calculated for the PATH wild stocks by dividing the number of harvested fish plus spawner escapement totals by the number of smolts produced 5 years earlier. The number of smolts were calculated using a density-dependent, egg-to-smolt relationship applied to the number of spawners identified that year. These rates were then applied to all wild Snake River stocks and modeled for each alternative. The results of this modeling are presented graphically in Figure 3.5-2. The PATH indicator SAR rate of change was also used to identify the change in hatchery SARs from Year zero onward.

3.5.3 Allocation to Fisheries

There are three basic distribution patterns of Columbia River Basin produced salmon: north-turning fish (fall chinook), south-turning fish (coho), and some that tend to migrate in either direction (some of the above). Steelhead tend to scatter and migrate as on far as Russian waters. Harvest rates by geographic area depend on migration patterns, as well as on historic fishing patterns, and on international and historic treaties and management policies. The same reports used in calculating survival rates are used to calculate historic geographic and gear harvest shares. The distributional assumptions used for this economic analysis are that future harvests will reflect recent historical catches. These assumptions, however, depend on present Columbia River, U.S.-Canada, and Indian treaty allocations. Harvest allocation treaties change. The PST was being renegotiated at the time of this analysis. As a result, this analysis uses existing U.S. and Indian tribal agreements as the base for allocating harvests. What may be available after these obligations are met is distributed according to historical harvest distributions.

The economic effects of changing anadromous harvest depend on the user group and the geographic area where harvest takes place. Table 3.5-2 shows the 1986 to 1995 average in-river harvest rates, based on run size measured at ocean escapement. The in-river and ocean user group distributions used in the modeling are shown in Table 3.5-3. These tables must be carefully interpreted if compared, because of the basis of the shares. Treaty rights are for 50 percent of the harvestable fish, regardless of the geographic area. Treaty harvests have consistently fallen below the treaty right share for composite (wild and hatchery) Snake River summer steelhead. To provide a realistic transition to this distribution, a 25-year trend was used. This means that summer steelhead recreational mainstem (about 10,000 fish) and tributary harvest (about 40,000 fish) are held relatively constant during the 25-year transition period. After the transition period, both treaty and recreational harvests grow proportionally.

Run sizes can be measured at ocean escapement or at other geographic locations. The major anadromous fish stock's wild-origin run size measured at escapement past the uppermost dam on the lower Snake River over a recent historical period (1964-1996) and forecasts over the first 50 years of project life for each alternative are shown in Figures 3.5-3 through 3.5-6. Ocean and in-river harvests as well as other river passage mortalities have been accounted for in the wild run sizes. The forecasts show rapid recovery during the early project period and minor fluctuations in later years. These fluctuations, as explained by PATH documentation, are due to ocean regime shifts. The forecasted wild origin-run sizes are less than about one-third of the pre-dam historical levels.



Notes:
1. The Y-axis maximums are different for each species.
2. Smolt-to-adult rates are referenced as indicators because they are not based on age structures. The indicator rates are spawners, prespawning mortality, and harvest divided by smolts produced 5 years earlier and expressed as a percent. Smolts are calculated using a density-dependent, egg-to-smolt relationship and the number of spawners 5 years earlier.
3. Summer steelhead rates are based on changes to spring/summer chinook changes.
4. A1 through A4 refer to Alternatives 1 through 4

Figure 3.5-2. Snake River Wild-Origin Fish Smolt-to-Adult Survival Rate Indicators by Alternative during Project Period

Table 3.5-2. Snake River Anadromous Fish In-river Harvests and Harvest Rates for 10-year Average, 1986-1995

		Existing Inriver Harvest and Harvest Rates									
		Mainstem						Tributary			
		Commercial Non-Treaty		Recreational		Treaty Indian		LWG Escapement		Tributary Recreational	
Species/Stock	**Ocean Escapement**	**Number**	**Rate**	**Number**	**Rate**	**Number**	**Rate**	**Number**	**Rate**	**Number**	**Rate**
Snake River											
Fall Chinook											
Wild	1,813	—	—	—	—	419	23.1%	381	21.0%	—	—
Hatchery	4,458	—	—	—	—	1,108	24.9%	1,679	37.7%	—	—
Total	**6,271**	**803**	**12.8%**	**159**	**2.5%**	**1,527**	**24.3%**	**2,060**	**32.8%**	**—**	**—**
Spring Chinook											
Wild	8,657	—	—	—	—	561	6.5%	5,126	59.2%	—	—
Hatchery	19,865	—	—	—	—	1,363	6.9%	12,234	61.6%	—	—
Total	**28,522**	**506**	**1.8%**	**364**	**1.3%**	**1,924**	**6.7%**	**17,360**	**60.9%**	**—**	**—**
Summer Chinook											
Wild	3,073	00.0%	—	—	78	2.5%	2.5%	2,294	74.6%	—	—
Hatchery	2,856	00.0%	—	—	89	3.1%	3.1%	1,972	69.0%	—	—
Total	**5,929**	**00.0%**	**3**	**0.0%**	**167**	**2.8%**	**2.8%**	**4,265**	**71.9%**	**—**	**—**
Summer Steelhead											
Wild	21,187	0	0.0%	0	0.0%	4,115	19.4%	16,225	76.6%	0	0.0%
Hatchery	105,598	0	0.0%	10,733	10.2%	25,972	24.6%	72,795	68.9%	40,248	38.1%
Total	**126,785**	**0**	**0.0%**	**9,846**	**7.8%**	**29,636**	**23.4%**	**89,020**	**70.2%**	**40,248**	**31.7%**

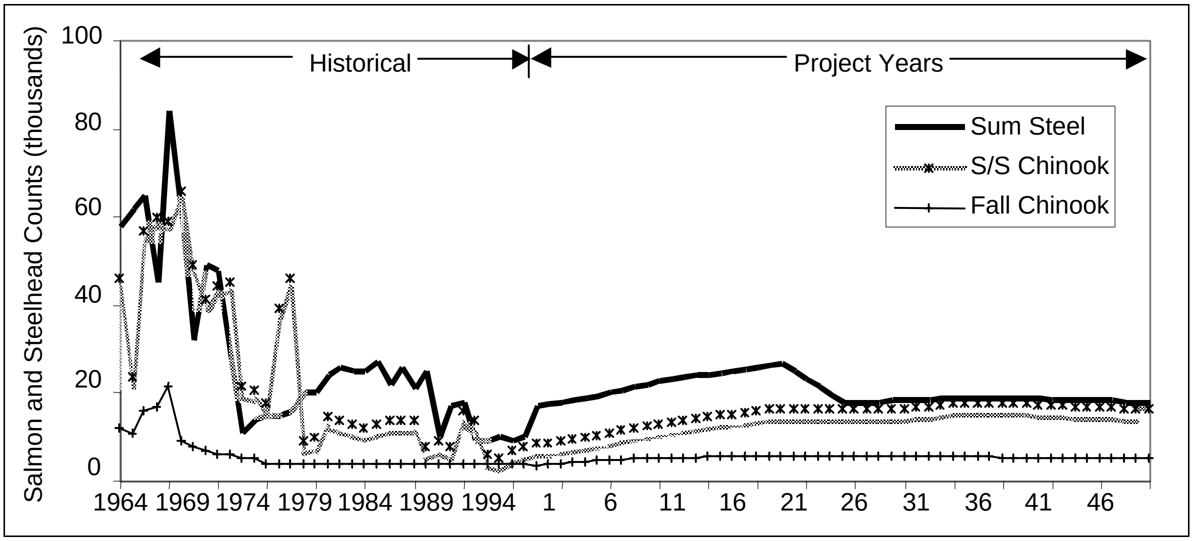
Note:
1. Averages are based on 1986 through 1995 period.
2. Harvest rates are based on ocean escapement.
3. Upriver refers to mainstem escapement from the lower Columbia River into either the Upper Columbia River or the Snake River.
4. All references to specific tables and tabs are found in TAC 1997.
5. Recreational mainstem and tributary harvests are assumed to be illegal and zero for wild fall chinook, spring chinook, and summer chinook after 1990 and for summer steelhead after 1984.
6. Fall chinook
   a. Total fall chinook harvest from commercial, recreational, and treaty user groups is from Table 8, Tab E.**???** The assumption is made that catch in zone 6 is treaty.
   b. Ocean and Lower Granite Dam escapement is from Tables 8 and 9, Tab 3.
   c. Treaty harvest of wild fall chinook is from Table 9, Tab 3. Hatchery harvest is the residual of total and wild salmon.
7. Spring chinook
   a. Total ocean escapement is the total upriver run size times and the proportion of Snake River spring chinook from Tables 1 and 2, Tab 1.
   b. Wild ocean escapement and LWG escapement are from Tables 2 and 3, Tab 1.
   c. Hatchery LWG escapement is from Table 3, Tab 1.
   d. Total commercial and total recreational Snake River harvests are estimated using upriver spring chinook mainstem harvests by user group and applying the proportion of mainstem escapement to Snake River.
   e. Treaty harvest of wild mainstem Snake River spring chinook is from Table 2, Tab 1. It is assumed that harvests in zone 6 are treaty harvest only. Total harvest is estimated using harvest of upriver spring chinook and a proportion of Snake River spring chinook. Treaty harvest of hatchery spring chinook is the residual of total and wild fish.
8. Summer chinook
   a. Wild ocean escapement and LWG escapement are from Table 2, Tab 2.
   b. Hatchery ocean escapement and LWG escapement are from Table 3, Tab 2.
   c. Total recreational mainstem harvest of summer chinook is estimated from harvest of upriver summer chinook and a proportion of Snake River summer chinook.
   d. Non-treaty commercial harvest in zones 1-5 for wild and hatchery summer chinook is zero. Table 1, Tab 2. Incidental non-retention is excluded.
   e. Treaty harvest of wild summer chinook is from Table 2, Tab 2. This assumes zone 6 harvest is treaty-only.
   f. Treaty harvest of hatchery summer chinook is from Table 3, Tab 2. This assumes zone 6 harvest is treaty-only.
9. Summer steelhead
   a. Non-treaty commercial harvest is assumed to be zero.
   b. LWG escapement is from Tables 12 through 15, Tab 8. Lower Granite counts of group A and B were summed (based on the length method).
   c. Total tributary harvest is from Tables A1c and A1d.
   d. Wild hatchery ocean escapement is from Tables 12 through 15, Tab 8. Lower Granite with no mainstem fishery counts of group A and B were summed (based on the length method). This provides a minimum run size.
   e. Mainstem harvest rates are assumed to equal mainstem harvest rates for total upriver summer steelhead stocks.

Source: TAC 1997.

Table 3.5-3. Assumptions for Anadromous Fish User Group Distributions by Species and Geographic Area

	Anadromous Species		
	Chinook		
Geographic Area/User Group	**Spring/Summer**	**Fall**	**Summer Steelhead**
Ocean Harvest			
Alaska			
a) Commercial	0.000%	11.663%	0.000%
b) Sport	0.000%	0.002%	0.000%
British Columbia			
a) Commercial	0.000%	48.506%	0.000%
b) Sport	0.000%	3.880%	0.000%
Subtotal Alaska/B.C.	0.000%	64.051%	0.000%
Washington ocean			
a) Commercial	0.000%	19.027%	0.000%
b) Sport	0.000%	8.456%	0.000%
Washington Puget Sound			
a) Commercial	0.000%	0.002%	0.000%
b) Sport	0.000%	0.002%	0.000%
Oregon			
a) Commercial	0.000%	6.343%	0.000%
b) Sport	0.000%	2.115%	0.000%
California			
a) Commercial	0.000%	0.002%	0.000%
b) Sport	0.000%	0.002%	0.000%
Subtotal WOC Ocean	0.000%	35.949%	0.000%
Subtotal Ocean	0.000%	100.000%	0.000%
In-river Harvest			
Treaty Year 0	50.000%	62.219%	37.200%
Year 5	50.000%	62.219%	39.760%
Year 10	50.000%	62.219%	42.320%
Year 15	50.000%	62.219%	44.880%
Year 20	50.000%	62.219%	47.440%
Year 25-100	50.000%	62.219%	50.000%
Non-treaty			
Mainstem	(less treaty)		(less treaty)
a) Freshwater sport	77.000%	2.874%	100.000%
b) Commercial non-treaty	17.000%	34.491%	0.000%
c) Other in-river Tributary	6.000%	0.416%	0.000%
Tributary			
a) Freshwater sport	100.000%	0.000%	100.000%
Returns to Hatcheries			
Requirement to Carcass	100.000%	100.000%	100.000%
Surplus			
a) Carcass and egg sales	50.000%	50.000%	50.000%
b) Food fish	50.000%	50.000%	50.000%

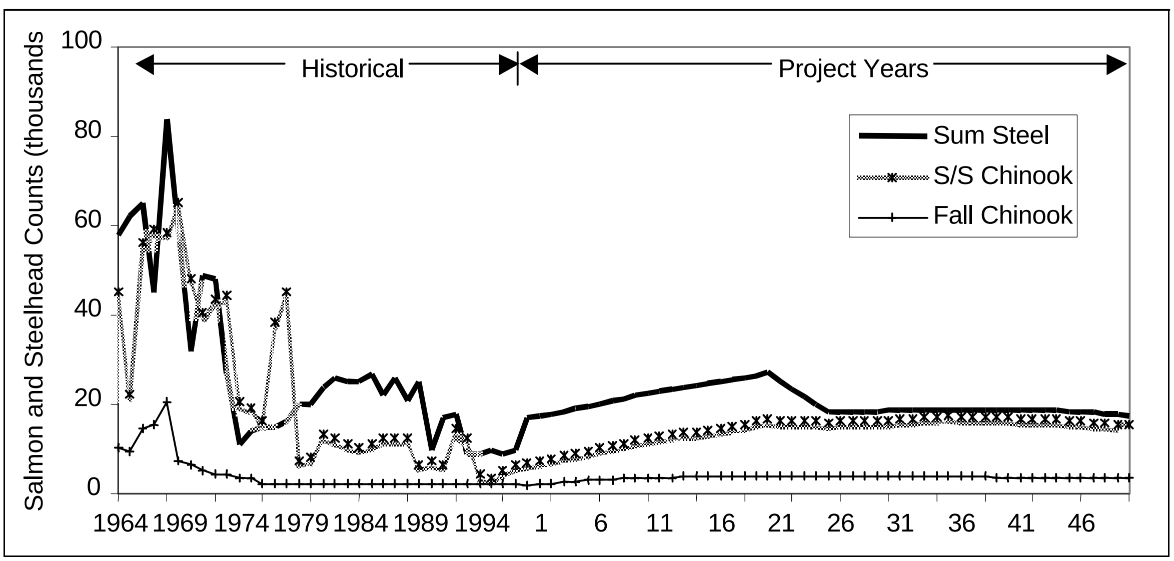
1/ Expressed as percent of fish harvested by the geographical fisheries.
2/ Results assume 50% for treaty harvests and zero ocean harvests for spring/summer chinook and summer steelhead.
3/ Treaty harvest percent of fish is based on all in-river harvestable fish (mainstem and tributary). It is assumed that all treaty harvests are in the mainstem.
4/ Non-treaty mainstem harvests for spring/summer chinook and summer steelhead represent the distribution of the remaining mainstem harvestable fish by user group.
5/ Non-treaty harvests for fall chinook represent shares of total in-river harvest.



Note: Adult wild salmon and steelhead counts at the uppermost dam on the Snake River below Lewiston (Ice Harbor Dam 1964-68, Lower Monument Dam 1969, Little Goose Dam 1970-74, Lower Granite Dam 1970-74).

Source: DREW Anadromous Fish Workgroup, 1999, and IDFG (1998).

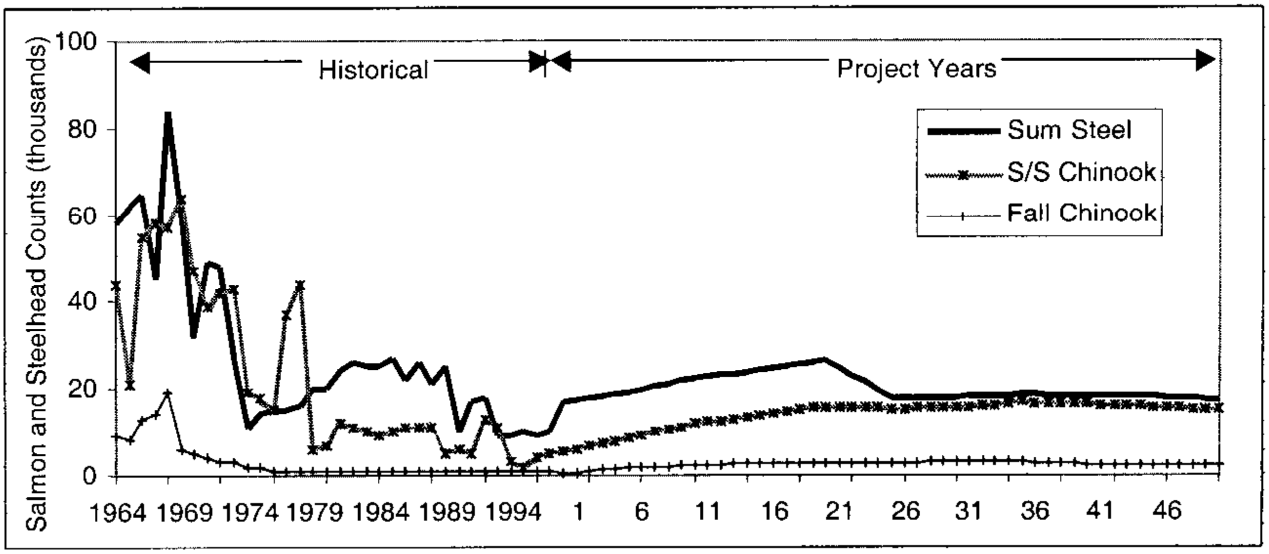
Figure 3.5-3. Historical and Project Year Wild-Origin Stock Run Counts at Snake River Uppermost Dam, Alternative 1, Existing Conditions



Note: Adult wild salmon and steelhead counts at the uppermost dam on the Snake River below Lewiston (Ice Harbor Dam 1964-68, Lower Monument Dam 1969, Little Goose Dam 1970-74, Lower Granite Dam 1970-74).

Source: DREW Anadromous Fish Workgroup, 1999, and IDFG (1998).

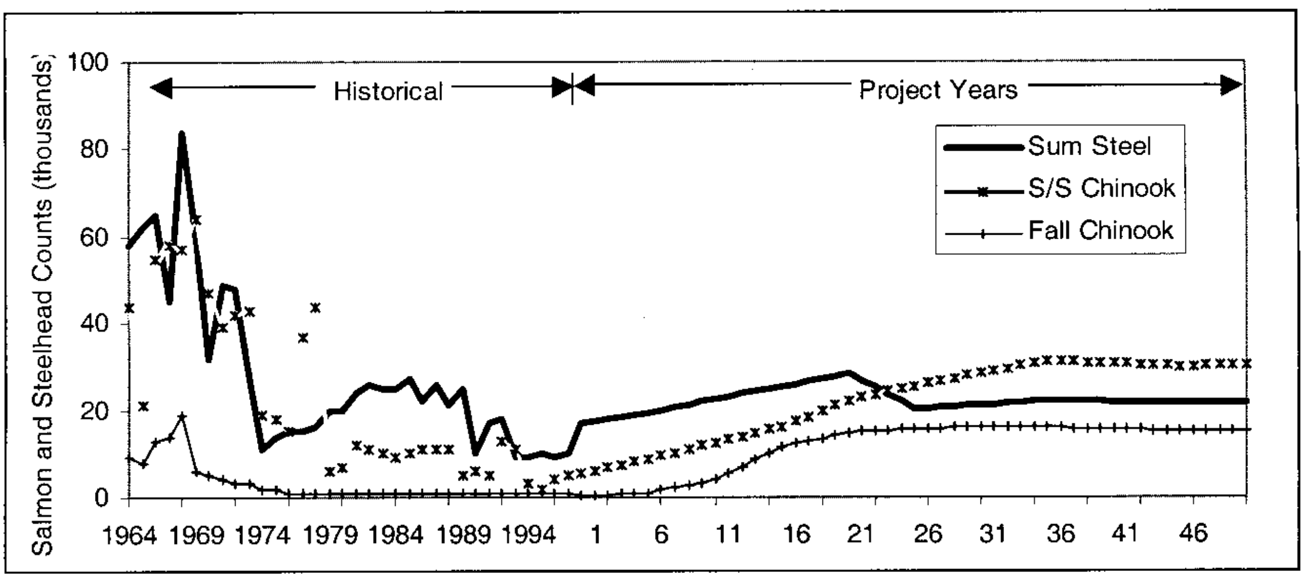
Figure 3.5-4. Historical and Project Year Wild-Origin Stock Run Counts at Snake River Uppermost Dam, Alternative 2, Maximum Transport of Juvenile Salmon



Note: Adult wild salmon and steelhead counts at the uppermost dam on the Snake River below Lewiston (Ice Harbor Dam 1964-68, Lower Monument Dam 1969, Little Goose Dam 1970-74, Lower Granite Dam 1970-74).

Source: DREW Anadromous Fish Workgroup, 1999, and IDFG (1998).

Figure 3.5-5. Historical and Project Year Wild-Origin Stock Run Counts at Snake River Uppermost Dam, Alternative 3, Major System Improvements



Note: Adult wild salmon and steelhead counts at the uppermost dam on the Snake River below Lewiston (Ice Harbor Dam 1964-68, Lower Monument Dam 1969, Little Goose Dam 1970-74, Lower Granite Dam 1970-74).

Source: DREW Anadromous Fish Workgroup, 1999, and IDFG (1998).

Figure 3.5-6. Historical and Project Year Wild-Origin Stock Run Counts at Snake River Uppermost Dam, Alternative 4, Dam Breaching

3.5.4 Economic Evaluation

The overall goal of this analysis is to calculate the economic values from harvesting those Columbia and Snake River anadromous fish stocks that are affected by the proposed alternatives. The results of this analysis are presented in terms of net economic value. Net economic value usually defines the value that someone, some group, or the nation may receive from an activity, over and above the cost of that activity. Both economic value and regional economic impacts are calculated over a 100-year project life. Annualized future values are discounted to Year zero using various interest rates. The current Corps rate is 6.875 percent, while the current Bonneville Power Administration (BPA) rate is 4.75 percent. Indian tribes generally do not discount future generation benefits, i.e., they use a zero percent interest rate. Values are annualized using the Corps definition for annual average equivalent values. All values are in 1998 dollars.

Values calculated on a per-fish basis differ, depending on the type of harvest. Commercial economic values or NED benefits are based on ex-vessel values. Seventy percent of ex-vessel revenue is used as an indicator of net economic value. Commercial fishing economic data were compiled about ex-vessel values (price paid to harvesters for their catch), primary processing prices, recovery rates, and costs of harvesting and processing for different species, gear, geographic areas, and user groups. Anadromous fish from the Snake River are commercially harvested by different means (troll—hand and power; net—gillnet, purse seine, and dip net) in different ocean areas (southeast Alaska, Canada, Washington, Oregon, and northern California), the Columbia River estuary, the main stem of the Columbia River, and its main tributaries. Primary seafood processing is included to evaluate the contribution at different stages of processing. For example, troll salmon are usually dressed and sold directly to processors. Net fish are usually sold to a fish buyer in the round. A tender, for a margin of 10 to 18 cents per pound, gathers the salmon and delivers them to the processors. Hatchery fish that escape harvesting return as hatchery surpluses. The surpluses are sold for eggs, carcasses, and sometimes food fish. The funds are usually returned to hatcheries to offset operating and capital improvement costs.

The recreational fishery value uses a benefit transfer approach to develop a value per angler day. This value is then multiplied by the number of angler days required to catch a fish. Available information on recreational fishing (success rates and trip expenditure patterns by trip mode, such as guided trips, etc.) associated with lower Snake River anadromous fish runs was compiled and synthesized. Angler days were determined using catch per unit effort (CPUE) data based on recent periods, which were then adjusted for abundance levels. The CPUE to determine angler days used recent period catch rates. Ocean recreational composite CPUE rates are 1 day per fish, Columbia River mainstem is 2 days per fish, and Snake River tributary is 5.88 days per fish. CPUE is influenced by fishing motivational factors and fishery management techniques. For example, all existing recreational steelhead fishing is selective for hatchery origin fish. If future wild-origin abundance levels allowed retention, then the CPUE (expressed as days per fish) would decrease. Modeling assumptions for CPUE incorporated decreasing tributary CPUE (expressed as days per fish) with increasing abundances. Economic value assumptions are presented for commercial and recreational fishing by species and fishery in Table 3.5-4.

The direct costs of commercial and recreational fishing and hatchery surplus sales were then related to economic values for the national economy. The changes in NED values associated with changes in anadromous fish harvest were calculated as annual average values over a 100-year period of analysis and presented as net of the base case (Alternative 1, Existing Conditions). These annual

Table 3.5-4. Economic Value (NED Benefits) Assumptions by Species and Fishery

Spring/Summer Chinook	Commercial	Recreational
Ocean		
Alaska	33.83	
British Columbia	34.30	
Washington ocean	23.68	
Washington Puget Sound	21.19	
Oregon	21.65	
California	22.33	
Columbia Basin inland		
Mainstem	49.95	51.43
Tributary		63.23
Other	0.00	
Food fish	26.87	
Carcass and egg sales	0.00	
Fall Chinook		
Ocean		
Alaska	33.83	51.43
British Columbia	34.30	51.43
Washington ocean	23.68	51.43
Washington Puget Sound	21.19	51.43
Oregon	21.65	51.43
California	22.53	51.43
Columbia Basin inland		
Mainstem	23.53	51.43
Tributary		
Other	0.00	
Food fish	18.25	
Carcass and egg sales	1.23	
Summer Steelhead		
Ocean		
Alaska		
British Columbia	11.44	
Washington ocean		
Washington Puget Sound		
Oregon		
California		
Columbia Basin inland		
Mainstem	9.99	52.85
Tributary		63.23
Other		
Food fish	8.73	
Carcass and egg sales	1.23	

1/ Average 1998 dollars per fish (commercial fisheries) and angler day (recreational fisheries).

2/ Carcass sales assume $0.10 per pound for whole body dressed weight.

average values were presented for Alternatives 2 through 4 using three different discount rates in Table 3.5-5. Using a 6.875 percent discount rate, NED benefits ranged from $0.16 million for Alternatives 2 and 3 to $1.59 million for Alternative 4, Dam Breaching. If a zero discount rate were used, the average annual benefits might reach $3.49 million. Most of the totals shown here would be generated from the in-river treaty fishery contributed by fall chinook. There would also be significant NED benefits associated with the in-river recreational fishery. These benefits are addressed in the analysis conducted by the DREW Recreation Workgroup (see Section 3.2). To give a more complete depiction of the sensitivity associated with data and modeling assumptions, the in-river recreational user group is included in the risk and uncertainty analysis presented in Section 3.5.5.

Table 3.5-5. Changed Annualized Economic Value (NED Benefits) Between Base Case and Other Hydrosystem Actions for Various Discount Rates (1998 dollars)

	Discount Rates					
	0%		4 6/8%		6 7/8%	
Alternative	**Amount**	**Order**	**Amount**	**Order**	**Amount**	**Order**
Annual Average Equivalent Value (Year zero to Year 100)						
2	$0.20	2	$0.18	2	$0.16	3
3	$0.19	3	$0.17	3	$0.16	2
4	$3.49	1	$2.06	1	$1.59	1

1/ NED benefits measured by annual average equivalent values over a 100-year project life in millions of 1998 dollars. Alternatives 2 through 4 are presented net of the base case (Alternative 1, Existing Conditions)

2/ Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus use. The evaluation excludes the economic values for in-river recreational fishing.

3/ The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook using "likely" (50th percentile) modeling output.

Average annual NED values are presented by species for wild- and hatchery-origin fish in Table 3.5-6. Values for presented for each alternative using "low," "likely," and "high" modeling results that correspond to PATH results for 25th, 50th, and 75th percentile modeling outputs, respectively. The average annual values were calculated using a 6.875 percent discount rate.

3.5.5 Risk and Uncertainty

The economic values from the Columbia River Basin anadromous fish runs are determined using forecasted harvests throughout their migration routes. The actual harvestable fish depends on the productivity of the inland water system, as well as the ocean system. Inland water system production factors can include harvesting methods, habitat alterations, hatchery production, hydrosystem operations, and ocean conditions. Strategies for recovery can address manmade factors, the more immediate remedies being harvesting methods, hydrosystem operations, and hatchery production. A short discussion of the variability in economic analysis results due to these factors is presented below. These factors are addressed in terms of markets, smolt-to-adult survival rates, and harvest management. Additional sections in this chapter discuss how the economic analysis results change based on using different PATH scenarios.

Table 3.5-6. Ranges of Annualized Economic Value (NED Benefits) by Fishery For Each Hydrosystem Action Using "Low," "Likely," and "High" Modeling Results (1998 dollars) ($1000s)

	Alternative 1			Alternative 2			Alternative 3			Alternative 4		
Anadromous Fish	**Low**	**Likely**	**High**	**Low**	**Likely**	**High**	**Low**	**Likely**	**High**	**Low**	**Likely**	**High**
Commercial												
Ocean												
Alaska	$6.15	$12.72	$26.35	$6.15	$12.72	$26.35	$6.85	$14.56	$30.54	$31.99	$69.48	$136.12
British Columbia	$25.93	$53.66	$111.09	$25.93	$53.66	$111.09	$28.90	$61.41	$128.77	$134.89	$292.97	$573.99
WA Ocean	$7.02	$14.53	$30.08	$7.02	$14.53	$30.08	$7.83	$16.63	$34.87	$36.53	$79.34	$155.44
WA Puget Sound	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.01
Oregon	$2.14	$4.43	$9.17	$2.14	$4.43	$9.17	$2.39	$5.07	$10.63	$11.13	$24.18	$47.38
California	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.01	$0.02
Subtotal Ocean	$41.24	$85.34	$176.70	$41.24	$85.34	$176.70	$45.97	$97.68	$204.82	$214.55	$465.99	$912.95
Inriver												
Non-treaty	$21.50	$45.76	$96.49	$23.09	$51.36	$110.14	$24.26	$52.75	$113.84	$120.47	$223.36	$409.35
Treaty Indian	$293.52	$702.77	$2,003.61	$323.81	$795.22	$2,062.65	$323.18	$789.90	$1,992.09	$564.64	$1,287.11	$2,771.28
Hatchery Returns	$8.77	$137.06	$522.24	$28.98	$198.78	$613.34	$25.47	$188.48	$567.35	$206.31	$480.92	$990.32
Subtotal Inriver	$323.79	$885.59	$2,622.34	$375.88	$1,045.36	$2,786.14	$372.92	$1,031.12	$2,673.27	$891.43	$1,991.39	$4,170.95
Subtotal Commercial	$365.02	$970.93	$2,799.04	$417.12	$1,130.70	$2,962.84	$418.89	$1,128.80	$2,878.09	$1,105.97	$2,457.38	$5,083.90

Table 3.5-6. Ranges of Annualized Economic Value (NED Benefits) by Fishery For Each Hydrosystem Action Using "Low," "Likely," and "High" Modeling Results (1998 dollars) ($1000s) Continued

	Alternative 1			Alternative 2			Alternative 3			Alternative 4		
Anadromous Fish	**Low**	**Likely**	**High**	**Low**	**Likely**	**High**	**Low**	**Likely**	**High**	**Low**	**Likely**	**High**
Recreational												
Ocean												
Alaska	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
British Columbia	$3.11	$6.44	$13.32	$3.11	$6.44	$13.32	$3.47	$7.37	$15.44	$16.18	$35.14	$68.84
WA Ocean	$6.78	$14.03	$29.04	$6.78	$14.03	$29.04	$7.55	$16.05	$33.66	$35.26	$76.58	$150.04
WA Puget Sound	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
Oregon	$1.70	$3.51	$7.26	$1.70	$3.51	$7.26	$1.89	$4.02	$8.42	$8.82	$19.15	$37.53
California	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.00	$0.00	$0.01	$0.01	$0.02	$0.04
Subtotal Ocean	$11.59	$23.98	$49.65	$11.59	$23.98	$49.65	$12.92	$27.44	$57.55	$60.28	$130.93	$256.51
Total Commercial and Recreational	**$376.61**	**$994.91**	**$2,848.68**	**$428.70**	**$1,154.68**	**$3,012.48**	**$431.81**	**$1,156.25**	**$2,935.64**	**$1,166.25**	**$2,588.31**	**$5,340.41**

1/ NED benefits measured by annual average equivalent values over a 100 year project life using 6.875% discount rate in thousands of 1998 dollars.

2/ Evaluation is for all modeled anadromous fish species and includes harvests and hatchery surplus utilization. The evaluation excludes the economic values for in-river recreational fishing.

3/ PATH results fall chinook Action A1 is the same as Action A2. Fall chinook is the only significantly harvested species in ocean fisheries.

4/ "Low," "likely," and "high" modeling results correspond to PATH results for 25th, 50th, and 75th percentile modeling outputs, respectively.

5/ The analysis is based on PATH results' "base case" scenario for fall chinook and "equal weights" scenario for spring/summer chinook.

6/ Total and subtotals may not equal sum of values due to rounding.

The economic value of recreational in-river fisheries calculated by the DREW Anadromous Fish Workgroup are included in the total NED benefits presented in the following sensitivity analysis, since much of the discussion concerns effects of harvest management, and the recreational in-river fishery is the highest contributor to economic values. In-river recreation NED benefits were also calculated by the DREW Recreation Workgroup based on original surveys conducted for this FR/EIS (see Section 3.2). These values are used for the overall NED analysis presented in this document. The values calculated by the DREW Anadromous Fish Workgroup were not included in this analysis to avoid double-counting. Compatibility issues surrounding these two analyses are briefly addressed in Section 3.5.6. The purpose of this risk and uncertainty section is to discuss the sensitivity of the results. Therefore, the change to the fishery's economic value should be relatively proportional, no matter what the estimated value.

3.5.5.1 Markets

Commercial Fishing

For centuries, salmon have sustained the people of the Pacific Northwest. They were an important food source, cultural symbol, and means of trade for American Indians. As western development took place, salmon runs provided jobs and income to harvesters, cannery workers, and related industries throughout the region. As water-based economic development took place in the Pacific Northwest, natural-based production was supplemented by artificial propagation.

Artificial propagation was at first limited to egg incubation. For some salmon species, in order to increase SAR, the propagation process included fry and later-smolt releases. Smolt production may cost $0.50 to $1.00 per smolt. The high cost of smolt production and low overall survival rates of free ranging salmon (salmon ranching) have led to rearing salmon in cages (salmon farming) where smolts will survive at about 80 to 90 percent. The farming process is now providing about 50 percent of the world salmon market. The price of salmon for the fresh and frozen market is now generally set by farmed salmon. These prices depend on markets, but also on the main ingredient in farming salmon, the feed costs. A range of substitutes is available; therefore, no dramatic changes are expected in the price level of commercial salmon produced from the Columbia River Basin.

More variation may be expected in use of a substantial portion of the anadromous fish that return as "surplus" and are not harvested. For wild fish, this presently is not a problem. However, in some cases, returns to hatcheries beyond what is needed for propagation are a resource that could provide additional benefits to the Pacific Northwest region.

According to lower Columbia River processors, about 50 percent of the fall returning fish and 100 percent of the summer returning fish could be used for developed markets (personal communication with processor facility operators, April 1999). Development of markets would include the traditional fresh and frozen markets, as well as value-added products, such as ready-to-purchase fillet steaks and ready-to-eat portions. Other specialty products might also include canned and smoked products. Egg production for the Japanese market might also have a significant potential (Radtke and Davis, 1996).

The model's existing assumptions assume 50 percent of hatchery return surplus goes to egg and carcass sales and 50 percent for food fish. The change in analysis results for hydrosystem actions for developed markets (zero percent carcass sales and 100 percent use for food fish) is about a

$180 thousand or 1 percent gain in average annual NED benefits for Alternative 4, Dam Breaching. Changing the analysis results for a zero percent hatchery utilization results in a $400 thousand loss in average annual NED benefits for Alternative 4, Dam Breaching.

Recreational Angling

Since World War II, there has been a steady increase in outdoor activity in the West. Between 1945 and the early 1970s, recreation activity on public lands grew by more than 10 percent per year, driven by rapid population growth, increased affluence, improvements in cars and interstate highways, decreased real gasoline prices, increased air travel, and the decline of the average work week to 40 hours and 5 days (Walsh 1986). Population growth and the proportion of that population having a degree of affluence are the most significant factors contributing to the increases in recreation activity (English et al. 1993). The significant population increases expected for the West suggest that there may be major increases in recreation activity related to public resources in the future (Haynes and Horne, 1996).

In general, the assumption of one fish per day is used in this evaluation of the benefits of recreational angling in ocean fishing. Past studies of ocean salmon fishing suggest that this success rate is a reasonable representation of historical trends. Since salmon/steelhead fishing has been curtailed inland during the last few years, no clear studies of motivation factors, such as fishing success rates needed to attract anglers, have been completed. The Oregon Department of Fish and Wildlife (ODFW) uses a one-fish-per-day success rate for ocean fishing and up to 2-day-per-fish success rates for inland fishing (Carter, 1999). The State of Idaho conducts annual surveys of anglers (Bowler, 1999). For tributaries above the Columbia River/Snake River confluence, a 2-day-per-fish success rate for wild, non-retained, and hatchery-retained fish has been experienced. For retained steelhead only, the day-per-fish ratio has been 5.88. A study by Reading (1999) suggests that the average success rate for anadromous fish in Idaho is one fish for about 6.5 days of fishing. Future demand for outdoor recreation suggests that a success rate as low as 10 days per fish may be enough to attract anglers to fish for anadromous fish in some inland waters.

Using a range of success rates or CPUE provides a wide range of potential benefits related to the anadromous resources of the Columbia Basin. The change in analysis results for hydrosystem actions is considerable. Changing to a success rate of three days per fish slightly lowers the average annual NED benefits (Table 3.5-7 and Figure 3.5-7), because model assumptions use a tributary summer steelhead CPUE of 5.88 in Year zero trended to a CPUE of 2 over 30 years. Changing the success rate to 10 days per fish increases average annual NED benefits by about double.

3.5.5.2 Smolt-to-Adult Survival Rates

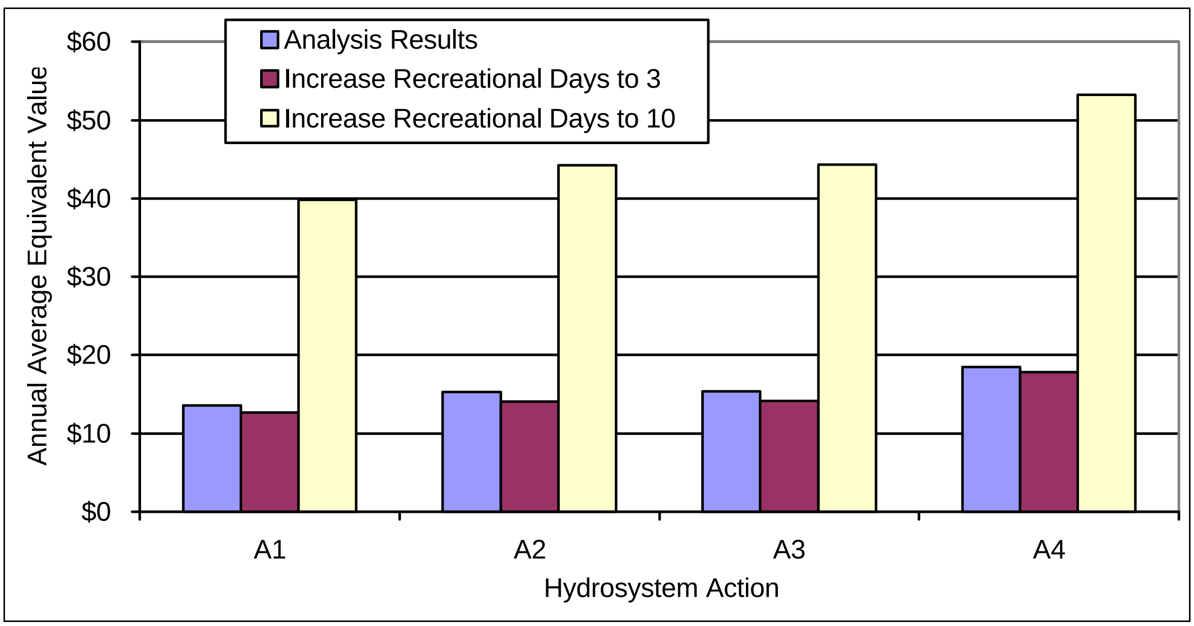
Smolt production and resulting adult harvests are the base for evaluating fishery benefits. The PATH results did not generate SARs as modeled outputs. It was possible to generate an indicator SAR using the 5-year increment outputs of harvests and spawners. These SARs are referenced as indicator rates because insufficient information about age-structures, interdam mortality, and other factors was available to determine a more precise rate. The wild-component indicator SARs by

Table 3.5-7. Annualized Economic Value (NED Benefits) for Alternative Hydrosystem Actions with Different Angler Success Rate Assumptions (1998 dollars)

	Hydrosystem Action			
Category/Alternative	**1 ($)**	**2 ($)**	**3 ($)**	**4 ($)**
Analysis Results				
AAEV	13.59	15.27	15.33	18.46
Recreational Inland: Success Rate 3				
AAEV	12.64	14.08	14.10	17.78
Difference from analysis results	(0.95)	(1.18)	(1.23)	(0.68)
Recreational Inland: Success Rate 10				
AAEV	39.82	44.25	44.29	53.24
Difference from analysis results	26.22	28.99	28.96	34.78

Note: NED benefits measured by annual average equivalent value over a 100-year project life in millions of 1998 dollars.

AAEV = Average Annual Equivalent Value



Note: NED benefits measured by annual average equivalent value over a 100-year project life in millions of 1998 dollars.

Figure 3.5-7. Annualized Economic Value (NED Benefits) for Alternative Hydrosystem Actions with Different Angler Success Rate Assumptions species and hydrosystem action are shown in Table 3.5-8. These wild component indicator SARs generally show the large increase necessary to attain the PATH results for forecasted spawners. In general, there must be a sevenfold increase in the indicator SARs for spring/summer chinook and a two to threefold increase for fall chinook between the initial project years and at Year 50 for spawners to be at the level forecast by PATH. Economic values would be significantly affected by a lesser improvement.

3.5.5.3 Harvest Management

Hatchery Production

It is assumed that hatchery management is based on past mitigation agreements and that hatchery release goals are defined by the present NMFS cap on hatchery releases. The role of supplementation hatcheries is not specifically included in the evaluation.

If natural resource-based recreation increases as discussed earlier, a challenge to management may be to convert hatchery surplus to inland recreational angling. The interplay between the conversion of hatchery surplus to recreational fishing and using different CPUE is shown in Table 3.5-9 and Figure 3.5-8. The CPUE, expressed as days per fish, generally decreases with increasing abundances. This is because increasing abundances generally mean harvest management would allow a more liberal bag limit (i.e., five fish per week rather than two). If the CPUE will changed to be slightly lower than the existing analysis, shifting hatchery surpluses would increase average annual NED benefits by about 40 percent.

Table 3.5-8. Wild Smolt-to-Adult Survival Indicator Rates by Species and by Hydrosystem Actions for Selected Project Years

	Survival Rate Indicators	
	Project Year 5 (%)	**Project Year 50 (%)**
Spring/Summer Chinook		
A1	0.468	4.422
A2	0.514	4.495
A3	0.537	4.788
A4	0.557	10.850
Fall Chinook		
A1	1.889	7.195
A2	1.889	7.195
A3	1.877	8.385
A4	0.940	30.850
Summer Steelhead		
A1	0.173	1.636
A2	0.190	1.663
A3	0.199	1.772
A4	0.206	4.014

Note: Project year survival rate indicators are adult spawners and pre-spawning mortality plus harvest divided by smolts produced 5 years earlier expressed as a percent.

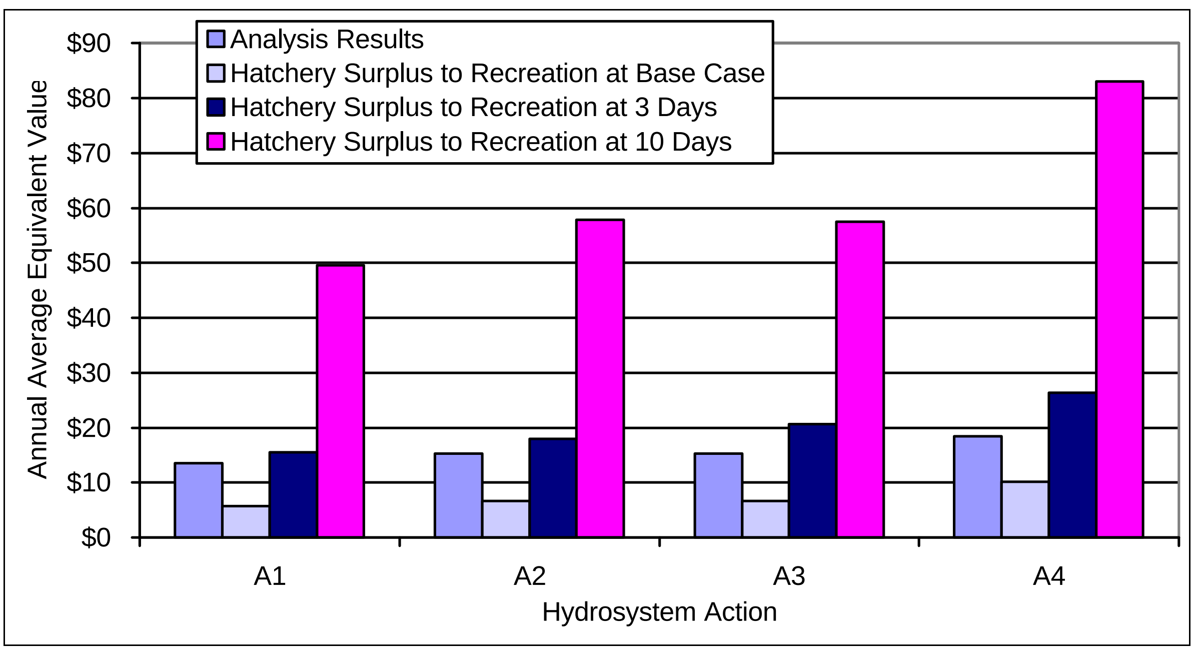
Source: Study and Petrosky and Schaller (1998).

Table 3.5-9. Annualized Economic Value (NED Benefits) for Alternative Hydrosystem Actions with Different Harvest Management Assumptions (1998 dollars)

	Hydrosystem Action			
Category/Alternative	**1 ($)**	**2 ($)**	**3 ($)**	**4 ($)**
Analysis Results				
AAEV	13.59	15.27	15.33	18.46
Convert Hatchery Surplus to Inland Recreational: Success Rate 1				
AAEV	5.75	6.66	6.64	10.22
Difference from analysis results	(7.85)	(8.60)	(8.69)	(8.24)
Convert Hatchery Surplus to Inland Recreational: Success Rate 3				
AAEV	15.49	18.04	20.71	26.40
Difference from analysis results	1.90	2.78	5.38	7.94
Convert Hatchery Surplus to Inland Recreational: Success Rate 10				
AAEV	49.59	57.88	57.49	83.05
Difference from analysis results	35.99	42.61	42.16	64.59

Note: NED benefits measured by annual average equivalent value over a 100-year project life in millions of 1998 dollars.

AAEV = Average Annual Equivalent Values



Note: NED benefits measured by annual average equivalent value over a 100 year project life in millions of 1998 dollars.

Figure 3.5-8. Annualized Economic Value (NED Benefits) for Alternative Hydrosystem Actions with Different Harvest Management Assumptions

Under the NMFS cap, hatchery releases are to be below 197 million smolts per year. "The total hatchery production in 1999 is projected to range from 140 to 150 million smolts, down from the 185 to 195 million range of 1996 to 1998 releases. These reductions are due to ESA concerns, fiscal cutbacks, and the failure of some hatchery programs to receive enough spawning escapement in the last 2 years." (Pollard, 1999). This is, in effect, a 25 percent reduction in hatchery releases. Unless wild fish production increases, a reduction of about 25 percent in economic benefits could be anticipated if this reduction in hatchery release continues. The other expectation may be that decreased hatchery releases increases wild fish survival and that the reduction in hatchery releases increases the number of returning wild spawners, which, in turn, increases overall production.

User Group Allocations

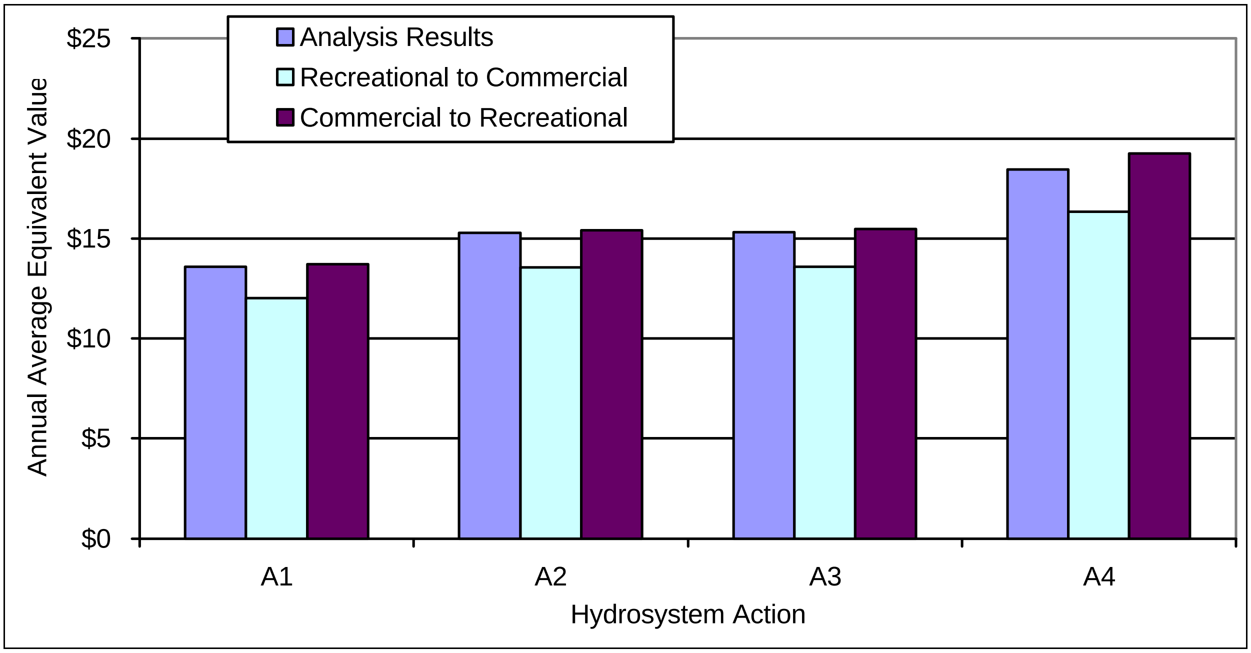
The situation for shifting Snake River production between user groups is complicated because of the overriding influence of summer steelhead contributions to fisheries. There is very little non-treaty commercial use for steelhead. Spring/summer chinook do not have a significant ocean commercial fishery and have not had a viable river gillnet fishery since the late 1980s. Therefore, converting all species from recreational to commercial fisheries would have little effect on increasing economic values from commercial fisheries (Table 3.5-10 and Figure 3.5-9).

Table 3.5-10. Annualized Economic Value (NED Benefits) for Alternative Hydrosystem Actions with Different User Group Allocations (1998 dollars) ($1,000)

	Hydrosystem Action			
Category/Alternative	**1 ($)**	**2 ($)**	**3 ($)**	**4 ($)**
Analysis Results				
AAEV	13.59	15.27	15.33	18.46
Convert Recreational to Commercial				
AAEV	12.02	13.54	13.60	16.34
Difference from analysis results	(1.58)	(1.73)	(1.72)	(2.12)
Convert Commercial to Recreational				
AAEV	13.73	15.41	15.49	19.24
Difference from analysis results	0.14	0.15	0.16	0.78

Note: NED benefits measured by annual average equivalent value over a 100-year project life in millions of 1998 dollars.

AAEV = Average Annual Equivalent Values



Note: NED benefits measured by annual average equivalent value over a 100-year project life in millions of 1998 dollars.

Source: Study.

Figure 3.5-9. Annualized Economic Value (NED Benefits) for Alternative Hydrosystem Actions with Different User Group Allocations

3.5.5.4 PATH Result Scenarios

The PATH process developed a large set of simulations based on different harvest management, smolt-to-adult survival rates, and other modeling factors. The combinations of assumptions were categorized under several scenario titles, including “equal weights” and “experts.” The latter refers to a panel of four experts (called the Science Review Panel, or SRP), which provided weights to seven different hypotheses about life-cycle modeling factors (Marmorek and Peters, 1998). Each of the four simulations that resulted from the weighting was averaged to be the mean-of-expert results. The PATH result scenario for mean-of-expert only applies to spring and summer chinook. NMFS suggests using the newer data and standard statistical methods instead of the expert panel approach (NMFS, 1999).

The simulations made to satisfy the weighting schemes by the SRP were anticipated, because the research would be used to validate or reject the PATH process. While the mean-of-expert scenario is not used in the analysis, the scenario can be useful for showing the range that occurs when using a different base to calculate the economic consequences. Table 3.5-11 shows the average annual NED benefits for the fall chinook, base-case scenario and the spring- and summer-chinook, mean-of-experts scenario. The equal-weights scenario results have slightly higher changed net average annual NED benefits for all of the proposed alternatives. Using the mean-of-experts scenario does not change the order of the alternatives. NED benefits would be larger for Alternative 4, Dam Breaching, under both scenarios.

Table 3.5-11. Changed Annualized Economic Value (NED Benefits) between Base Case and Other Hydrosystem Actions Using Different PATH Scenarios

	Discount Rates					
	0%		4 6/8%		6 7/8%	
Alternative	**Amount ($)**	**Order**	**Amount ($)**	**Order**	**Amount ($)**	**Order**
AAEV Equal Weights						
2	0.97	2	1.56	3	1.67	3
3	0.86	3	1.59	2	1.73	2
4	8.65	1	5.81	1	4.87	1
AAEV Mean of Experts						
2	-0.64	3	-0.35	3	-02.6	3
3	-0.04	2	0.40	2	0.51	2
4	8.36	1	5.35	1	4.35	1
Difference						
2	1.61		1.92		1.93	
3	0.90		1.19		1.22	
4	0.30		0.46		0.51	

1/ NED benefits measured by annual average equivalent value over a 100-year project life in millions of 1998 dollars. Alternatives 2 through 4 are presented net of the base case (Alternative 1, Existing Conditions).

2/ Negative values mean the base case (Action A1) benefits are greater than the hydrosystem actions being compared.

AAEV = Average Annual Equivalent Values.

3.5.6 Unresolved Issues

Several data, model development, and research coordination issues remained to be resolved completion of this analysis. These issues include the following:

- PATH result. The PATH results used in this analysis were based on the most recent available data at the time. PATH is continuing to investigate the effects of hydrosystem actions, and new PATH results are forthcoming. The new results will reflect improved modeling assumptions and methods.
- Fish forecast modeling procedures used to expand PATH results. PATH information for calculated SAR and Year zero may be available in future PATH result releases. This information will preclude some study modeling assumptions used in this analysis for these factors. Some analysts have commented that the assumptions for starting SARs and Year zero abundances using the most recent 10-year period for which complete information is available (1986 to 1995) are too high. Other analysts commented that, with a 100-year forecast horizon, a longer period base average is required.
- PATH result scenarios. This analysis and the recreation and tourism analysis used the PATH spring and summer chinook scenario results called “equal-weights.” The analysis for tribal circumstances used the PATH spring- and summer-chinook scenario results called “mean-of-

experts." Some analysts argue that PATH results based on the expert opinions about key PATH model assumptions reflect better science and should be used by all researchers. NMFS (1999) recommends that the expert opinion PATH results be disregarded.

- Economic methods used to evaluate fisheries. For estimating net economic value for commercial harvests, this analysis relies on an accepted approach used by other agencies. The PFMC and others use a percentage of the ex-vessel value as a proxy. Analysts disagree on the appropriate size of this percentage. If the number of additional fish that can be harvested is small, then they could be harvested with no additional effort by fishermen or increase in capacity of the commercial fishery fleet. In this situation, then, 100 percent of the ex-vessel value represents the net economic value. However, if the additional amount of fish made available by the project causes fishermen to use more fuel, labor, or other factors of production, then some lower percentage of ex-vessel value should be used as a proxy for net economic value. This analysis assumes a 70 percent ex-vessel value as a proxy to account for contribution from the harvest sector, the processing sector, and other affected businesses. However, some analysts argue that the percentage should be higher to account for the use of labor from tribal areas, for example, where there are high levels of unemployment, because the opportunity cost of such labor is zero. In such instances, relationships would have to be made specific to each fishery (troll, gillnet, non-tribal, and tribal).
- Coordination with the recreation and tourism analysis. The analysis for general recreation and tourism used different data and methods. The results may not be directly transferable for comparison or roll-up to results presented in this analysis. In particular, the recreational and tourism analysis assumptions concerning angler trip length, trip expenditures, success rates, and angler day benefits are different. The general recreation and tourism analysis also assumes success rates are steady-state (do not vary with increasing run sizes) and that survey results applicable to the lower Snake River area apply to mainstem Columbia River recreational fishing. Better alignment of the anadromous fish analysis and general recreation and tourism analysis could be achieved with adjustments to the angler motivation and choice modeling variables, geographic study areas, and data used for model specification.
- Future fisheries management regimes. This analysis is based on current management regimes in determining harvest levels, fishery effects, and allocations among user groups. Several treaties, court decisions, and other governance understandings are being considered for changes. For example, the PST is currently being negotiated. It is expected that this treaty will soon be adopted, and accordingly, that the results of the PST should be incorporated into this analysis.
- Treaty harvest. The harvest forecast distributional assumptions used by this analysis for ocean and in-river treaty commercial fisheries include ceremonial and subsistence (C&S) harvests. There is concern that double counting may result if C&S harvests are itemized in separate tables in other analyses.

Unresolved issues when related research is being undertaken by separate researchers is not uncommon. Based on further discussion among researchers and comments from the public, appropriate analytical revisions may need to be completed to make results consistent across all study elements.

3.6 Tribal Circumstances (NED)

There are 14 Native American tribes and bands in the region that could be potentially affected by the actions taken to improve fish passage and survival along the lower Snake River. These are the:

Confederated Tribes of the Colville Indian Reservation

Confederated Tribes of the Umatilla Indian Reservation

Confederated Tribes and Bands of the Yakama Nation

Nez Perce Tribe

Wanapum Band

Burns Paiute Tribe

Confederated Tribes of the Warm

Kalispel Indian Community of the Kalispel Reservation

Northwestern Band of the Shoshoni Nation

Hall Reservation

Shoshone-Paiute Tribes of the Duck

The Spokane Tribe of the Spokane Reservation.

Five of these tribes —

Yakama Indian Nation, the Confederated Tribes of the Warm Springs Reservation of Oregon, and the Shoshone-Bannock Tribes were selected for specific input because of their close cultural and economic links to the salmon. Impacts to tribal circumstances may be viewed in terms of tribal

tribes. A Tribal Circumstances and Perspectives report was prepared by a private consultant in association with the Columbia River Inter-Tribal Fisheries Commission (CRITFC). According to

spiritual purposes — and secondly to feed their people. The salmon were abundant – and they were also traded and exchanged for other valued goods, both within each tribe, and with peoples from other tribes.

As the salmon have declined, the "surpluses" available to the tribes for trading and commercial — — have declined toward zero. The Tribal

study tribes. The Shoshone-Bannock bands, who live furthest upriver of the five study tribes, have an absolute prohibition against the commercial sale of salmon. The Nez Perce Tribe, whose

selling salmon commercially after ceremonial and subsistence needs are met. In recent years, this has meant little or no sale of salmon harvested above the dams. The peoples of the Yakama, Nez

Tribal harvest in this zone supports a minimal level of commercial sales activity. Current harvests are identified for the five study tribes in Table 4-2.

commercial sales of salmon provides important income to tribal peoples, it does not represent the greatest part of value that tribal peoples associate with salmon. For example:

> Salmon is very important to our Indian lives. I have trouble with thinking of salmon only as dollars. You can't drink dollars. You can't eat dollars. Salmon is important to our spiritual life. It helps our spirit survive.
>
> (Terry Courtney, Jr., Warm Springs Fish Commissioner)

Dollar revenue is considered by the tribes to be a severely limited indicator of tribal value and can provide distorted impressions of the full impact on tribes. As a result, the Tribal Circumstances and Perspectives report provides a qualitative assessment of the alternatives considered as part of this FR/EIS. The key findings of this qualitative assessment are summarized in Section 5 of this appendix. A much lengthier discussion is provided in the Tribal Circumstances and Perspectives report (Meyer Resources, 1999a). From the perspective of the WRC guidelines that inform the overall economic analysis conducted as part of this FR/EIS (see Section 1.3), the discussion presented in Section 5 is part of the environmental quality account, which addresses non-monetary effects on significant natural and cultural resources.

While it is not possible to assign dollar values to Tribal ceremonial and subsistence harvest or to the relationship between salmon and tribal culture, spirituality, material well-being, and health, dollar values are assigned to tribal commercial fish harvest as part of the NED economic analysis conducted by the Drawdown Regional Economic Workgroup (DREW) Anadromous Fish Workgroup. This analysis, summarized in Section 3.5, estimates the future value of Tribal commercial harvest as a percentage of the total run sizes projected under each alternative. These projections are based on preliminary PATH data extended by the DREW Anadromous Fish Workgroup to represent all Snake River wild and hatchery stocks. The National Marine Fisheries Service (NMFS) analysis uses more recent PATH data.

There are four outstanding issues associated with the tribal portion of the DREW Anadromous Fish Workgroup's analysis. First, the Anadromous Fish Workgroup's analysis assigns commercial harvest value to the majority of the projected tribal harvest. A small fraction of the projected runs are excluded from the commercial analysis but it is likely that tribal ceremonial and subsistence harvests comprise a larger share than assumed by the Anadromous Fish Workgroup's analysis. Assigning percentages of tribal harvest to different types of use — commercial, ceremonial, or subsistence — is complicated because the boundaries between these types of use are not always clearly defined. This could theoretically result in "double-counting" of ceremonial and subsistence harvest, which are also addressed qualitatively in Section 5.0. A second concern, raised on behalf of the tribes (Meyer Resources, 1999b), is that dollar values assigned to tribal commercial harvests by the Anadromous Fish Workgroup's analysis are not high enough. Third, the Tribal Circumstances and Perspectives report suggests that the projected fish runs may be overestimates because the PATH analysis is built from present-day conditions and fails to incorporate long-term negative trends in Columbia River/Snake River stock sizes. The report also suggests that the year zero assumptions, which were developed by the DREW Anadromous Fish Workgroup, likely exceed PATH's present conditions by approximately 34 percent for spring/summer chinook, and 43 percent for fall chinook (Meyer Resources, 1999a; 214). Finally, it should be noted that the DREW Anadromous Fish Workgroup's analysis is based on unweighted PATH data. The tribes prefer to use the PATH data that was weighted by the PATH Scientific Review Panel and consider the use of the unweighted numbers to be a "retreat from best science" (Meyer Resources, 1999a; 214). Due to concerns associated with the weighting process, unweighted PATH results were used in all other analyses for this feasibility study.

3.7 Flood Control

The following is a qualitative evaluation of the flood control impacts of the four dams in the lower Snake River project. A quantitative flood control analysis has been omitted from the Feasibility Study because flood control benefits are not currently provided by the lower Snake River dams. Flood control benefits would also not be provided under a dam breaching alternative. A flood control benefit is a reduction in river stage or flow due to project operations. This section describes current, and predicts future, flood conditions, and demonstrates that flooding after removing the earthen portions of the four lower Snake River dams would be no worse than under current operations or conditions.

3.7.1 Current Flood Control

The four lower Snake River dams (Ice Harbor, Lower Monumental, Little Goose, and Lower Granite) were authorized for power, recreation, irrigation, transportation and fish and wildlife. They are not authorized by Congress for flood control. The four dams that make up the lower Snake River project were designed to operate as run-of-the-river facilities within small pool fluctuation ranges. The maximum and minimum authorized pool operating limit elevations for the four dams are measured at the project forebay gage of each dam, except for Lower Granite, which is measured at the gage located at the confluence of the Snake River and Clearwater River at Lewiston, Idaho. The authorized operating pool elevations and corresponding storage contents for that elevation range are summarized in Table 3.7-1.

The total storage capability contained within the operating range for the four projects is 137,400 acre-feet when inflows are low and the pool elevations are nearly flat between the forebay gage and the upstream end of the project. The pool elevations refer to the water surface elevation at the project forebay, except for Lower Granite. Its pool elevation refers to the Snake-Clearwater confluence gage. The Biological Opinion specifies that the pool elevations be restricted to the one foot range above MOP; therefore, the total usable storage is approximately 33,500 acre-feet.

Table 3.7-1. Authorized Operating Pool Elevations and Storage Contents

Project	**(feet)**	**(feet)**	**(feet)**	**(acre-feet)**
	733.0		5.0	
Little Goose		638.0		48,900
	537.0		3.0	
Ice Harbor		440.0		24,900

the Columbia River. Dworshak's storage capability is 2,000,000 acre-feet, which is approximately 15 times greater than the total storage capability of the lower Snake River projects and approximately 60 times greater than the total usable storage.

These projects have not been used for flood control on the Columbia River in the past; however, the potential to use storage space that would become available during a partial lower Snake River drawdown operation was evaluated during the Columbia River SOR. All four lower Snake River dams must be drawn down for a flood control benefit to be realized at The Dalles (BPA, 1995). The drawdown referred to in the SOR was part of the partial drawdown system operation strategy

(SOS 6b). The proposed partial drawdown elevations for SOS 6b were below authorized operating limits, but still high above natural river levels at the project forebays.

The lower Snake River dams were not designed and are not operated to provide flood control benefits because flood control is not a congressionally authorized project use. According to the 1995 Columbia River System Operation Review (SOR) EIS (BPA, 1995), the projects are physically capable of providing a minor benefit under a partial drawdown operation strategy, but only when coupled with major reconstruction of the projects. The reconstruction would be necessary to continue current congressionally authorized uses and operation of fish passage facilities. The Dworshak project located upstream on the Clearwater River currently provides congressionally authorized flood control benefits for the lower Snake River and further downstream on the Columbia River.

Before the project storage below the authorized operating limits (for a non-dam breaching alternative) could be used for flood control, each project's facilities would have to be rebuilt. This would include the spillways, powerhouse intakes and outlets, navigation facilities, fish facilities, and reservoir embankments. For example, the 1992 Lower Granite drawdown test demonstrated that the turbines would be damaged by excessive vibration and the transportation facilities would be damaged by slumping reservoir embankments.

A dam breaching alternative, which would involve removal of the earthen portions of each of the four dams, would not provide a flood benefit because there would be no reservoirs on the lower Snake River to store flood waters. There would be no physical capability to control flooding on the lower Snake River, except by Dworshak Dam, on the Clearwater River. The current Biological Opinion specifies that the lower Snake River pools elevations are to remain within one foot of the minimum operating pool (MOP) elevation. This precludes the current projects from storing flood waters, which makes the current flood control capability the same as it would be under a dam breaching alternative.

3.7.2 Future Flood Control

Future flood stages without the four lower Snake River dams in place would be no worse (higher) than the current flood stages. Removing the earthen portions of the dams would lower future water surface elevations down to natural river levels from the current pool elevations. This reduction would be greatest at the project forebays and least at the project tailwaters; therefore, local flood control benefits would be provided, particularly at the project forebays. This benefit would not be provided downstream of Ice Harbor Dam. Removing the earthen portions of the dams would eliminate the potential to operate the project for flood control; however, this potential was never authorized and would be cost prohibitive due to the major project reconstruction that would be required to maintain authorized uses. Dworshak will continue to provide flood control benefits in the lower Snake River and downstream on the Columbia River.

The upstream extent of flood control effects due to removing the earthen portion of the dams would reach the Lewiston area. Lower Granite Dam creates a backwater upstream to Lewiston. Levees were constructed in this area to provide navigation and power generation benefits. They were not constructed to provide flood control benefits. No future water surface reduction would result from removal of the earthen portion of Lower Granite Dam, and no subsequent flood control benefit would be provided, upstream of the backwater currently created by the project.

Under Alternative 4, Dam Breaching, the tailwater elevation downstream of Ice Harbor Dam would be approximately the same as under current conditions. The upstream extent of backwater in the lower Snake River, due to McNary Dam on the Columbia River, typically does not reach Ice Harbor Dam. Public comments during outreach meetings with the Corps have included claims of flooding in the Burbank area prior to dam construction. Current flood control benefits near Burbank are provided by Dworshak, which will continue to the provide flood control benefits to the Burbank area in the future.

These flood control benefits are not expected to be reduced if the earthen portions of the dams are removed, unless the channel and floodplain are filled in by subsequent sediment deposition. These sediments would be scoured from the reservoir beds and banks of the four lower Snake River dams, during and after removal, and transported downstream. There is not enough information available to quantitatively evaluate, and accurately predict, flood control impacts due to deposition of sediments near the Columbia-Snake confluence (Reese, 1998). The Corps is proposing to monitor and measure sediment deposition near this confluence to mitigate for this potential impact.

Another potential change in future flood control benefits would result from changes in the operation of Dworshak. The issue lies in the amount of water released from Dworshak Reservoir for the purpose of flow augmentation in the lower Snake River. Flow augmentation reduces the potential for excessive low flows in the lower Snake River, as well as enhancing fish habitat by increasing water velocity and reducing water temperature. Currently, the details of the amount of flow augmentation included in the future alternatives, the subsequent changes in Dworshak operations, and the resulting impact on flood control are not known.

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3.8 Implementation/Avoided Costs

3.8.1 Introduction and Study Organization

The purpose of this section of the analysis is to describe and display the *equivalent average annual costs* associated with implementation and avoided costs for each of the study alternatives under consideration. These costs are presented as equivalent average annual costs. The following discussion is divided into six sections: discussion of alternatives, implementation costs, average annual costs, avoided costs, risk and uncertainty, and other considerations.

3.8.2 Discussion of Alternatives

The construction and acquisition costs associated with each of the four alternatives are presented in Table 3.8-1. These costs are:

- based on the detailed project schedule PB-2A and Appendix D and E engineering annexes (Annexes A through D)
- at the concept level, based on a 100-year life cycle analysis
- developed at a price level October 1, 1998 (e.g., the start of the fiscal year) and adjusted to the year 2005 which is the starting year of construction.

Table 3.8-1. Total Construction & Acquisition Costs by Study Alternative (1998 dollars) ($1,000)[1/]

Alternative	Detailed Description	Starting Year	Construction & Acquisition Costs ($)
1 - Existing Conditions	Adaptive Management Strategy	2005	97,990
2 - Maximum Transport of Juvenile Salmon	Maximum Transport	2005	74,693
3 - Major System Improvements	SBC with Maximum Transport (low cost)	2006	167,972
4 - Dam Breaching	Channel Bypass or Natural River Alternative	2007	809,530

1/ These costs have been adjusted to base year 2005 using the 6.875 percent discount rate.
SBC—Surface Bypass Collectors
Source: U.S. Army Corps of Engineers, Walla Walla District

The starting dates of the various alternatives, indicating when each project will be functional, range from 2005 to 2010. However, it should be noted that this schedule is based on the following assumptions:

- that a record of decision will be made with work commencing in FY 2001
- that funding and other limitations will not impact the implementation schedule.

Failure to reach a record of decision or delays for any other reason will delay the starting date of the projects.

3.8.2.1 Comparison of Annual Implementation & Avoided Costs

Annual implementation and avoided costs are presented for the four alternatives in Figure 3.8-1. The annual costs for the dam breaching alternative are higher than those for the other alternatives from 2001 through 2009 because annual construction costs to breach the dams are significantly larger than the construction costs associated with improving the existing system. Construction costs are, however, completed for all alternatives by the year 2009. From 2010 until the end of the study period (2104) the on-going annual implementation and avoided costs are lower under the dam breaching alternative than under the other three alternatives.

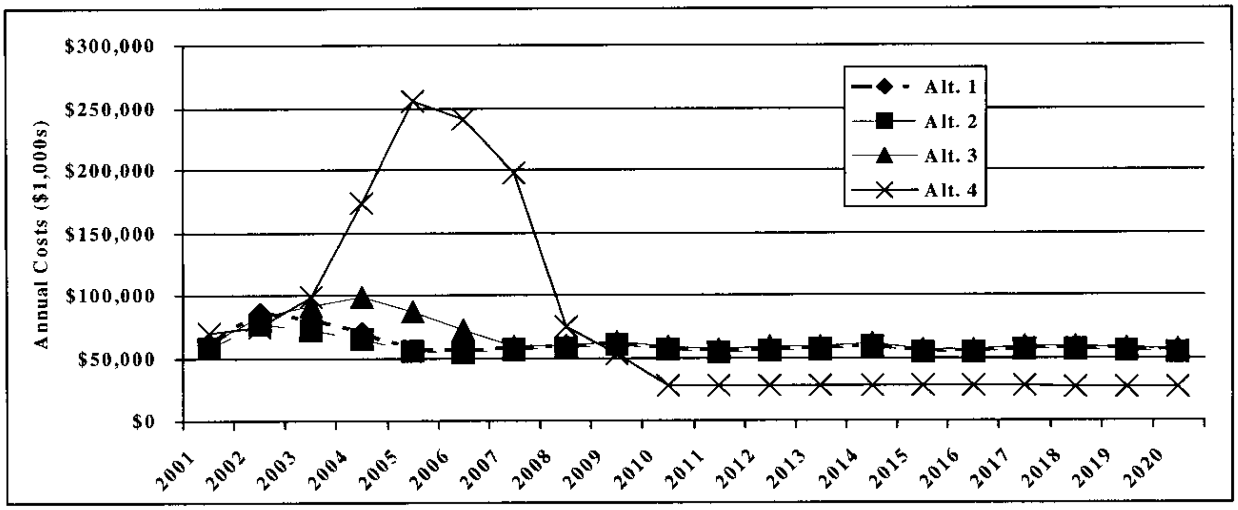

Figure 3.8-1. Comparison of Annual Implementation & Avoided Costs

3.8.3 Implementation Costs

Implementation costs considered in the following discussion include all project-related construction and acquisition costs and operation, maintenance, repair, replacement and rehabilitation costs (O,M,R,R&R) associated with construction and operation activities required under each alternative. Implementation costs also include mitigation costs for fish and wildlife programs, cultural resources, and tribal responsibilities. Mitigation costs are discussed in more detail in Section 12, Compensatory Actions.

Construction and acquisition costs are presented by major cost category for each alternative in Table 3.8.2.

3.8.3.1 Construction and Acquisition Costs for Dam Retention Alternatives

Improvements designed to enhance the performance of existing fish facilities are planned for Alternative 1, Existing Conditions, Alternative 2, Maximum Transport, and Alternative 3, Major System Improvements. Improvements proposed to reduce fish fatality at the turbines at each of the four dams include cam field test improvement studies and related cam improvements on the turbines. Each of the dams has six turbines, which would be sequentially improved. The cost to study and enhance the cams is estimated to be $3.5 million, as shown in Table 3.8-2. In addition, there are a series of fish-related improvements planned for each dam including:

Table 3.8-2. Total Construction & Acquisition Costs Adjusted to Base Year 2005 (1998 dollars) ($1,000)*

Cost Category by Alternative	1	2	3	4
Improvements to Existing Fish Facilities				
Gantry Crane Modifications	630	630	630	---
Fish Facility Cylindrical Dewatering System	1,433	1,430	1,430	---
ESBS Modifications	1,780	1,780	1,780	---
Cam Improvements and Studies	3,546	3,546	3,546	---
Trash Boom	5,280	5,280	5,280	---
Separator Improvements	7,262	7,260	7,260	---
Additional Barges & Moorage Cells	9,270	9,270	9,270	---
Aux. Water Supply Fish Ladder	10,805	10,805	10,805	---
Degasification Efforts	33,676	10,384	10,384	---
Juvenile Fish Facility Improvements	24,308	24,308	24,308	---
Sub-total	98,000	74,693	74,693	---
Additional New Fish Facility Improvements				
Prototypes, Testing of surface bypass collectors (SBC)	---	---	1,024	---
New Extended Screen Bypass (ESB) Screens	---	---	32,718	---
Full Flow Bypass SBC w/ Modified Spillbay	---	---	59,537	---
Sub-total	---	---	93,279	---
Dam Breaching Construction Costs				
Real Estate (Excessing Property)	---	---	---	841
Project Dam Decommissioning	---	---	---	5,006
Cultural Resources Protection	---	---	---	5,999
Cattle Watering Facilities	---	---	---	6,030
Drainage Structures Protection	---	---	---	8,830
Lyons Ferry Hatchery Modifications	---	---	---	9,047
HMU Modification	---	---	---	8,841
Recreation Access Modification	---	---	---	12,509
Railroad Relocations	---	---	---	21,913
Power House Turbine Modifications	---	---	---	30,952
Reservoir Revegetation (For Air & Water Quality)	---	---	---	26,336
Temporary Fish Handling Facilities	---	---	---	37,018
Bridge Pier & Abutment Protection	---	---	---	48,321
Railroad and Roadway Damage Repair	---	---	---	95,538
River Channelization	---	---	---	123,446
Dam Embankment Removal	---	---	---	158,775
Reservoir Embankment Protection	---	---	---	184,432
Sub-total	---	---	---	783,834
Mitigation Costs	---	---	---	25,696
Total	97,990	74,693	167,972	809,530

* These costs have been adjusted to base year 2005 using the 6.875 percent discount rate.
Source: U.S. Army Corps of Engineers, Walla Walla District

- Auxiliary water supplies for fish ladders—these improvements at each of the four lower Snake River projects would result in a total cost of $10.8 million across all four projects.
- Fish facility cylindrical de-water systems, which are needed at Ice Harbor, Lower Monumental and Little Goose but not at Lower Granite, are expected to cost $460,000 per affected project or $1.4 million for all three affected projects.
- Gantry crane modifications are needed at Lower Monumental, at a cost of $630,000.
- Juvenile fish facility improvements, which are needed at Lower Granite, are expected to cost $24.3 million.
- Separator improvements, which are needed at Lower Monumental and Little Goose, are expected to cost approximately $7.3 million in total.
- De-gasification improvements (DGAS) at Lower Monumental, Little Goose and Lower Granite, have already been implemented at Ice Harbor. These improvements, which include adding end bay deflectors and modifying the deflectors and pier extensions, are planned to decrease gasification and improve water quality. Under the base case, the cost of these improvements is $33.7 million across all projects.
- Improvement to the Trash boom (used to pickup trash and debris at the project) at Little Goose dam, at a cost of $5.3 million.
- Additional barges and improved barge moorage cells at Lower Granite, which are intended to improve and enhance the fish transportation program, are expected to cost $9.3 million (e.g., $6.7 million for five additional barges and $2.6 million for an improved barge moorage cell).
- Extended screen bypass systems (ESBS) are expected to cost $1.8 million.

Additional Fish Facility Improvements (Alternative 3, Major System Improvements)

Additional major systems improvements are planned under Alternative 3. These include conducting studies and installing extended screen bypass collection systems (ESBS) at the Ice Harbor, Lower Monumental, and Lower Granite dams. These improvements are estimated to cost $93.3 million.

3.8.3.2 Construction and Acquisition Costs for Alternative 4, Dam Breaching

The implementation costs associated with Alternative 4, Dam Breaching, are summarized in this section. The construction costs associated with this alternative are also summarized in Table 3.8-2. The construction process includes modifying, removing, or protecting structures (e.g., roads, railroads, bridges, reservoir embankments, drainage structures, recreation access corridors, the hatchery at Lyons Ferry and like structures) that would remain after the dams are breached. The largest construction costs are for dam embankment removal and river channelization, which in combination, exceed $70 million at each of the dams. Each dam embankment is scheduled for removal concurrently over a three-year period between 2004 and 2007. There would be a need to shore up the reservoir embankment prior to water release to prevent the undermining of the riprap and structures along the banks once the river is returned to a natural state. There would also be a need to re-vegetate the newly exposed banks of the river. In addition, before the dams are breached, temporary fish handling facilities would be needed.

The power house turbine modifications identified in Table 3.8-2 would allow a controlled release of the water in the reservoirs behind the dams and are not the same as the turbine rehabilitation projects under dam retention strategies. Also planned is modification of cattle watering corridors,[11] modification of habitat management units (HMUs), and protection of cultural resources after dam breaching and river channelization.

Mitigation Costs (Alternative 4, Dam Breaching)

The mitigation costs under Alternative 4, Dam Breaching, include those associated with fish and wildlife habitat mitigation efforts and cultural resources preservation associated with preserving and protecting habitat and cultural sites such as burial grounds.

3.8.3.3 O, M, R, R&R Costs for Dam Retention Alternatives

In addition to construction costs, O,M,R,R&R costs would also occur with implementation of the project-related or fish-improvement components of Alternatives 1 through 3. Some of the costs are associated with studies and others are related to operation and maintenance of the fish-improvement systems. The efforts to maintain and enhance existing fish-related facilities and operations are summarized in Table 3.8-3 and include:

- Continued study of anadromous fish (called the anadromous fish evaluation program or AFEP) involves a process for testing, research and evaluating how well the proposed improvements meet fish-improvement goals and objectives. The AFEP study costs occur for approximately 25 years during construction and rehabilitation improvements. Total AFEP costs adjusted to base year 2005 are expected to range from a low of $55 million under Alternative 2, Maximum Transport of Juvenile Salmon, to a high of $88 million under Alternative 3, Major System Improvements.

- BOR water acquisition costs allow an increased volume of water to pass over the dams during critical flow periods. The water is purchased from natural (irrigator) flow rights, changes in Snake River reservoir operations, and additional water from BOR storage reservoirs. Water purchases are expected to continue to occur throughout the study period to meet flow requirements, at an estimated total cost of $43 million over the 100-year study period adjusted to base year 2005 for the existing flow augmentation requirement of 427,000 acre feet (AF) of water.

- Total maintenance costs associated with screen bypass collector systems for Alternative 3, Major System Improvements, are expected to cost $10 million over the 100-year life of the project adjusted to base year 2005.

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[11] It should also be noted here that cattle watering corridor modification costs were included in the implementation costs because of deed requirements. Refer to the Engineering Appendix for further details regarding what constitutes implementation costs.

Table 3.8-3. Total Project-Related O, M, R, R&R Costs (1998 dollars) ($1,000)*

Cost Category by Alternative	Alternative 1 ($)	Alternative 2 ($)	Alternative 3 ($)	Alternative 4 ($)
Anadromous Fish Evaluation Program	82,413	55,488	88,516	38,428
BOR Water Purchase	43,300	43,300	43,300	43,300
Wildlife Monitoring	---	---	---	179
Vegetation Monitoring	---	---	---	382
Fish Monitoring Costs	---	---	---	32,442
Water Quantity Monitoring Costs	---	---	---	6,094
Air Quality Monitoring Costs	---	---	---	504
Sedimentation Monitoring Costs	---	---	---	1,553
Fish Improvement Related, Dam Operation, Maintenance and Repair	---	---	10,068	---
Total	125,713	98,788	141,884	122,882

* Costs are adjusted to base year 2005 using the 6.875 percent discount rate.
Source: U.S. Army Corps of Engineers, Walla Walla District

3.8.3.4 O, M, R, R&R Cost for Alternative 4, Dam Breaching

In addition to the mitigation and construction/acquisition costs, there are ongoing operation and maintenance (O&M) costs associated with the continued anadromous fish evaluation program, the purchase of water by the BoR, and the monitoring costs associated with dam breaching. These costs are also summarized in Table 3.8-3. Total AFEP costs for the 100-year period of study are estimated to be $38 million and monitoring costs are estimated to equal $41,160, as adjusted to the base year 2005.

3.8.4 Average Annual Costs

3.8.4.1 Average Annual Costs of Fish Facility Improvements

This section presents a summary of the total and average annual implementation costs. Construction, IDC, AFEP and O,M,R,R&R costs are displayed in average annual equivalent terms taking into account the 100-year period of analysis and adjusted to base year 2005 in Table 3.8-4.

Costs incurred during the period of analysis were discounted to the beginning of this period using the applicable discount rates. Implementation costs incurred during the period of installation (following October 2000) were brought forward to the end of the installation period by charging compound interest at the applicable discount rate from the date that the costs were incurred. These costs were then converted into 1998 dollars and annualized to provide an average annual value for each alternative. This analysis presents average annual costs using three discount rates: the Corps' rate of 6.875 percent, the BPA rate of 4.75 percent, and 0.0 percent at the request of the five Tribes represented by CRITFC.

Table 3.8-4. Summary of Implementation Costs (1998 dollars) ($1,000s)

Discount Rate by Alternative	Construction and Acquisition Cost ($)	Interest During Construction Cost ($)	Total Investment Cost ($)	Average Annual Investment Cost ($)	Average Annual AFEP Cost ($)	Average Annual O,M,R,R&R Cost ($)	Average Annual Implementation Cost ($)
@ 6.875 Percent							
Alternative 1	89,258	8,732	97,990	6,745	5,673	2,984	15,402
Alternative 2	67,904	6,789	74,693	5,141	3,820	2,984	11,945
Alternative 3	151,939	16,033	167,972	11,563	6,093	3,677	21,333
Alternative 4	759,093	50,437	809,530	55,727	2,645	5,817	64,189
@ 4.75 Percent							
Alternative 1	89,258	5,971	95,229	4,567	4,498	2,759	11,824
Alternative 2	67,904	4,641	72,545	3,480	3,029	2,759	9,268
Alternative 3	155,021	11,131	166,152	7,969	4,831	3,400	16,200
Alternative 4	800,224	35,688	835,912	40,092	2,097	5,133	47,322
@ 0.0 Percent							
Alternative 1	89,258	0	89,258	893	1,373	2,423	4,689
Alternative 2	67,904	0	67,904	679	924	2,423	4,026
Alternative 3	162,384	0	162,384	1,624	1,474	2,981	6,079
Alternative 4	911,122	0	911,122	9,111	640	3,236	12,987

Source: U.S. Army Corps of Engineers (Walla Walla District, Portland District), BPA and BST Associates

The major cost categories include:

- Construction costs for fish-improvement projects and/or to breach the dams. Construction costs associated with the Alternative 4, Dam Breaching include mitigation costs, such as wildlife mitigation and cultural resources protection.
- Interest during construction (IDC), which reflects compound interest, at the applicable borrowing rate, on construction costs incurred during the period of installation,
- Anadromous fish evaluation program (AFEP), and,
- O,M,R,R&R costs associated with the new fish improvement projects (e.g., purchase of water from BOR and the O&M costs associated with the screen bypass system proposed under Alternative 3, Major System Improvements).

Average annual costs vary widely depending upon which discount rate is used but the ranking of the alternatives remains constant. Alternative 2, Maximum Transport of Juvenile Salmon, is the lowest cost alternative (in fact, it has a lower cost than the base case). Alternative 1, Existing Conditions and Alternative 3, Major System Improvements, are the next lowest cost alternatives, while Alternative 4, Dam Breaching, is the highest cost alternative, under all discount rates.

3.8.5 Avoided Costs

The avoided costs associated with each alternative include those costs that would no longer be required to operate and maintain the lower Snake River dams and associated lands. These costs are calculated by comparing the continued operation of the four lower Snake River lock and dams under the Base Case conditions (Alternative 1, Existing Conditions) with Alternatives 2 through 4. Costs under Alternative 1 that are not included in the other alternatives are considered avoided costs.

Avoided costs include:

- Avoided costs of construction or major upgrades that would occur with Alternative 1, Existing Conditions, but not under other alternatives. These include major powerhouse system upgrades, and, specific additional major improvements to fish bypass, collection and passage systems.
- Avoided O&M costs incurred under Alternative 1, Existing Conditions, but not under other alternatives. These include future annual O&M costs, and, additional annual repair costs.
- Disposition of equipment that could be surplused, if the dams were breached represents a third type of cost included in this analysis. This represents a reduced opportunity cost for other Federal agencies seeking this type of property and may, therefore, be considered a form of avoided costs.

3.8.5.1 Avoided Construction Costs

The major fish-improvement cost incurred under Alternative 1, Existing Conditions, that does not occur in Alternatives 2, 3, or 4 is the second phase of the de-gasification construction project (DGAS2). This project is required to reduce nitrogen saturation resulting from additional flows. It is not required under Alternatives 2 and 3 because these alternatives involve additional collection efforts above the dams that would reduce the need for additional spills and related system improvements. The additional construction cost associated with the DGAS2 project is approximately $21 million.

There are, however, additional costs associated with Alternatives 2 and 3 that are not required under Alternative 1, Existing Conditions. As a result, net avoided costs for fish-related improvements only occur under Alternative 2, Maximum Transport of Juvenile Salmon. These costs are, however, included in the comparison of implementation costs and would be double-counted if included again as avoided costs.

3.8.5.2 Avoided Non-Project Related OMRR&R Costs

Under Alternative 4, Dam Breaching, the earthen embankment of the four lower Snake River dams would be removed. As a result, the power house rehabilitation costs and the annual O&M non-project related costs associated with the base case (Alternative 1, Existing Conditions) would be significantly reduced. These are included as avoided costs under Alternative 4, Dam Breaching. The avoided costs under the Alternative 4 include:

- Avoided rehabilitation of the power houses at each of the four dams. Currently proposed rehabilitation includes all 24 turbine and generator units (including the turbines, the turbine blades, rewinding generators, and miscellaneous work). Over the study period, this rehabilitation is expected to cost approximately $380 million for the entire system. This effort is underway at the present time at Ice Harbor Dam, which was built earlier than the other three lower Snake River dams, and will be required again in approximately 50 years. The 24 lower Snake River dam turbine units have an approximate life span of 25 to 50 years. It takes approximately 10 years to rehabilitate the six turbine units at each dam and only one turbine unit can be rehabilitated at a time for several reasons (including the need to continue generating power during the rehabilitation process and funding limitations).

- Avoidance O&M and other minor repair activities are expected to average $25 million per year throughout the life of the system for those alternatives that retain dam operations. Some of the annual O&M costs, such as those associated with maintenance of HMUs and recreation facilities, would also occur under Alternative 4, Dam Breaching. In addition, the annual costs of $14.4 million to operate the Lyons Ferry fish hatchery would occur under all four alternatives (including Alternative 4). Avoided costs under Alternative 4, Dam Breaching, would be partially offset by the normal dam operating expenditures that would occur between 2001 and the actual dam breaching (2007). In addition, after dam breaching, there would be continuing O&M costs associated with the operation and maintenance of the existing HMUs and parks.

- Real property could be disposed of under Alternative 4 once the dams are breached. Personal property that is currently utilized at the lower Snake River projects could be transferred to other Federal agencies and hence represents another avoided cost of dam breaching. The total value of personal property at the lower Snake River lock and dams calculated for those items with a value greater than $2,500 is approximately $14.9 million.

3.8.5.3 Summary of Avoided Costs

The avoided costs associated with Alternative 4, Dam Breaching are approximately $29 million per year over the life of the study, under all discount rates, as shown in Table 3.8-5. Using the 6.875 percent discount rate as an example, the avoided costs are calculated by subtracting the sum of the annual costs for turbine replacement, O,M,R,R,&R costs, and surplus property value under the base case alternative (e.g., $64,783,000) from Alternative 4, Dam Breaching (e.g., $35,605,000) which equals an annual avoided cost of $29,178,000.

Table 3.8-5. Summary of Avoided Costs (1998 dollars) ($1,000s)

Discount Rate/ Alternative	Turbine Rehabilitation ($)	Non-Project Related O,M,R,R&R ($)	Surplus Property ($)	Sub-Total ($)	Avoided Costs ($)
@ 6.875 Percent					
Alternative 1	4,800	58,955	1,028	64,783	---
Alternative 2	4,800	58,955	1,028	64,783	---
Alternative 3	4,800	58,962	1,028	64,790	---
Alternative 3	---	35,605	---	35,605	(29,178)
@ 4.75 Percent					
Alternative 1	4,579	54,476	716	59,771	---
Alternative 2	4,579	54,476	716	59,771	---
Alternative 3	4,579	54,499	716	59,794	---
Alternative 4	---	30,428	---	30,428	(29,343)
@ 0.0 Percent					
Alternative 1	3,871	46,935	149	50,955	---
Alternative 2	3,871	46,935	149	50,955	---
Alternative 3	3,871	47,412	149	51,432	---
Alternative 4	---	21,905	---	21,905	(29,050)

Source: U.S. Army Corps of Engineers (Walla Walla District, Portland District), BPA and BST Associates

3.8.6 Risk & Uncertainty

The following section presents an evaluation of the risk and uncertainty associated with the implementation and avoided cost analysis. The range of uncertainty within each cost estimate is based on the following estimates of contingencies:

- 15 percent to 25 percent contingency range for construction and acquisition costs associated with the dam retention alternatives (with a most likely estimate of 20 percent),
- 25 percent to 35 percent contingency range for construction and acquisition costs associated with the dam breaching alternative (with a most likely estimate of 30 percent),
- 0 percent to 10 percent contingency range for O,M,R,R&R under all alternatives (with a most likely estimate of 5 percent),

3.8.6.1 Risk & Uncertainty in Average Implementation Costs

Based upon these contingencies, the range of costs for fish facility improvements is presented in Table 3.8-6. As shown, total average annual implementation costs (including all construction and other costs) range from $61.0 to $67.4 million under Alternative 4, Dam Breaching, with a most likely cost estimate of $64.2 million per year under a discount rate of 6.875 percent. The annual implementation costs net of the base case range from $46.3 to $51.2 million, with a most likely net cost of $48.8 million.

Table 3.8-6. Implementation Costs—Risk & Uncertainty (1998 dollars) ($1,000s)

Discount Rate/	Annual Implementation Costs ($)			Net of Base Case ($)		
Alternative	Most Likely	Low	High	Most Likely	Low	High
@ 6.875 Percent						
Alternative 1	15,402	14,632	16,172			
Alternative 2	11,945	11,348	12,542	(3,457)	(3,284)	(3,630)
Alternative 3	21,333	20,266	22,400	5,931	5,634	6,228
Alternative 4	64,189	60,980	67,398	48,787	46,348	51,226
@ 4.75 Percent						
Alternative 1	11,824	11,233	12,415			
Alternative 2	9,268	8,805	9,731	(2,556)	(2,428)	(2,684)
Alternative 3	16,200	15,390	17,010	4,376	4,157	4,595
Alternative 4	47,322	44,956	49,688	35,498	33,723	37,273
@ 0.0 Percent						
Alternative 1	4,689	4,455	4,923			
Alternative 2	4,026	3,825	4,227	(663)	(630)	(696)
Alternative 3	6,079	5,775	6,383	1,390	1,321	1,460
Alternative 4	12,987	12,338	13,636	8,298	7,883	8,713

Source: U.S. Army Corps of Engineers (Walla Walla District, Portland District), BPA and BST Associates

Under the same discount rate, the average annual implementation costs for the three dam retention alternatives are estimated to be as follows:

- implementation costs for Alternative 1, Existing Conditions, range from $14.6 to $16.2 million, with a most likely estimate of $15.4 million,

- implementation costs for Alternative 2, Maximum Transport of Juvenile Salmon, range from $11.3 to $12.5 million, with a most likely estimate of $11.9 million (e.g., ranging from a negative $3.3 to negative $3.6 million net of the base case), and,

- implementation costs for Alternative 3, Major System Improvements, range from $20.3 to $22.4 million, with a most likely estimate of $21.3 million (e.g., ranging from $5.6 to $6.2 million net of the base case).

3.8.6.2 Risk & Uncertainty in Average Annual Avoided Costs

Based upon a 5 percent contingency, the range of annual costs for non-project related operations, maintenance, repair, replacement and rehabilitation costs (O, M, R, R and R) are presented in Table 3.8-7. As discussed above, there are a number of on-going annual costs incurred in dam retention alternatives that are avoided under the Alternative 4, Dam Breaching.

Table 3.8-7. Avoided Costs—Risk & Uncertainty (1998 dollars) ($1,000s)

Discount Rate/ Alternative	Annual Non-Project Related Costs ($)			Avoided Costs ($)		
	Most likely	Low	High	Most likely	Low	High
@ 6.875 Percent						
Alternative 1	64,783	61,543	68,022			
Alternative 2	64,783	61,543	68,022			
Alternative 3	64,790	61,550	68,029			
Alternative 4	35,605	33,825	37,385	(29,178)	(27,719)	(30,637)
@ 4.75 Percent						
Alternative 1	59,771	56,782	62,760			
Alternative 2	59,771	56,782	62,760			
Alternative 3	59,794	56,804	62,784			
Alternative 4	30,428	28,907	31,949	(29,343)	(27,876)	(30,810)
@ 0.0 Percent						
Alternative 1	50,955	48,408	53,503			
Alternative 2	50,955	48,408	53,503			
Alternative 3	51,432	48,861	54,004			
Alternative 4	21,905	20,810	23,000	(29,050)	(27,598)	(30,503)

Source: U.S. Army Corps of Engineers (Walla Walla District, Portland District), BPA and BST Associates

Avoided costs are calculated by subtracting the annual costs associated with the base case from those associated with the dam breaching alternative. For example, the most likely annual avoided costs are calculated by subtracting the base case average annual costs of $64.8 million from the dam breaching average annual costs of $35.6 million, which equals ($29.2 million) at a discount rate of 6.875 percent. The average annual avoided costs range between $27.7 and $30.6 million, with a most likely cost estimate of $29.2 million per year under a discount rate of 6.875 percent.
Table 3.8-7 also presents the annual avoided costs under the 4.75 percent and 0.0 percent discount rates.

3.8.7 Other Considerations

3.8.7.1 Repayment of Outstanding Debt

The Bonneville Power Administration (BPA) repays to the Federal Treasury costs allocated to hydropower from the Federal dams. The capitalized costs of the project (e.g., initial construction costs, replacement costs) are repaid by BPA over a 50 year period at designated interest rates. The current debt associated with the lower Snake River lock and dams is approximately $479 million for construction of the dams as of the end of 1998. In addition, there is also additional outstanding debt for the lower Snake River fish hatcheries and fish mitigation funds of approximately $271 million as of the end of 1998. There is also a construction work in progress account that will transfer to BPA as new additional debt.

If the lower Snake River locks and dams are removed, it is possible that Congress, through the authorizing legislation, will reduce some or all of this long-term debt. It is not known at this time what might be written off, however, this debt-relief is not considered an avoided cost. The debt cost is sunk and a write-off would not avoid it but rather would simply transfer the debt to a different party. The issue of payment of outstanding debt is addressed further under the finance section of the cost allocation report (Section 12).

3.8.7.2 Relationship of Implementation Costs to NED Impacts

Estimates of the NED impacts of power, navigation, recreation, water supply and other study elements are presented in Sections 3.1 through 3.7 of this appendix. Care has been taken to eliminate potential double counting of costs. As an example, the avoided cost report documents the cost to operate the lower Snake River lock and dams under various dam retention alternatives. A major portion of this cost is for power facilities. Including the cost to provide power from the four lower Snake River dams in the power cost estimates would lead to a double counting of costs. Therefore, the costs of operating the existing plants are excluded from the hydropower analyses. Care has been taken in evaluating other NED impact estimates to assure that double counting is similarly avoided.

The avoided cost estimates indicated above have focussed on Federal costs. However, there could also be impacts to state and local governments, private sector individuals and firms, and the Tribes. The NED impact estimates should account for the avoided costs to other parties that could partially offset national cost increases. There may, however, be some costs that have not been captured in other study elements. One example is the cost to reconstruct the natural gas line that crosses lake Herbert G. West (Lower Monumental Reservoir). Under the Alternative 4, Dam Breaching, this reconstruction is estimated to cost $12.4 million. The study teams have not captured this cost. There may be other examples.

3.8.8 Unresolved Issues

The engineering cost estimates in this report are preliminary and may be adjusted between the draft and final FR/EIS.

With respect to avoided costs, the hydropower group is evaluating whether the reduction of the Canadian entitlement should be considered as an avoided cost.